BIOGRAPHICAL MEMOIRS OF FELLOWS OF THE INDIAN NATIONAL SCIENCE ACADEMY

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PREFACE

This is the nineteenth volume in the series of Biographical Memoirs containing sixteen deceased eminent fellows of the Academy specialising in different disciplines of physics, chemistry, botany, zoology, geography, geology and mathematics with notable contributions.

Professor AK Saha, an eminent Physicist, contributed to nuclear spectroscopy, nuclear magnetic resonance design and construction of instruments, analysis in molecular quantum mechanics and statistical mechanics. SM Ali, Professor of Geography, translated Reinaud's works on Arab Geography. AK Das, a renowned Physicist made meteorological measurement of cosmic ray and contributed in the field of astrophysics, geomagnetism, and inosphere. ML Roonwal, Professor of Zoology, worked on arthropoda, mammalia–major thrust in research on locusts and grasshoppers and termites. JB Auden, a Geologist, contributed on Himalayan geology, engineering geology and ground water geology. SSL Pradhan, a Zoologist, contributed on functional morphology in insects, insect toxicology, chemical control of crop pests. KS Thind, Professor of Botany, worked on taxonomy of fungi, agricultural importance of myxomycetes, discomycetes, hymenomycetes etc. and nutrition of pathogenic fungi. K Ramiah, an agricultural Botanist, founder Director, Central Rice Research Institute, Cuttack, worked on rice breeding, and cotton genetics. KS Singwi, Professor of Physics, worked in the field of quantum statistics, reactor physics and neutron physics. H Rakshit, Professor of Electronics and Electrical Communication Engineering, worked on radio wave propagation and O_2 and O_3 distribution in upper atmosphere. SV Anantakrishan, a renowned teacher in Chemistry, worked on reaction kinetics. V V Narlikar, an eminent teacher of Mathematics, had significent research achievements to his credit in the areas of relativity, cosmology and field theory. BN Ghosh, Professor of Chemistry, contributed on colloid, proteins, cobra venom and immuno chemistry. SN Das Gupta, a Botanist and founder Vice-Chancellor of Kalyani University contributed generously to the areas of mycology and fruit necrosis. BS Rao, Professor of Chemistry, specialized in colloid chemistry and the chemistry of sulphur. RBS Sewell's contribution covered zoological, geographical, oceanographical, anatomical and anthropological disciplines.

I wish to express my sincere thanks to the contributors of this volume, Editors of Publications - Professor OP Bhutani, and Professor TJ Pandian and to Dr. M. Dhara and Dr. (Mrs.) M. Chatterjee for bringing out this valuable volume.

December 1, 1994

SK JOSHI
President

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AJIT KUMAR SAHA

(1922-1991)

Elected Fellow 1959

AJIT KUMAR SAHA was a distinguished physicist of the country, who was widely recognised not only for his scientific contribution but also for his affectionate and encouraging patronage to the scientific pursuit of many younger scientists. He was largely instrumental in the growth and development of many front line areas of research in Saha Institute of Nuclear Physics. He was a man of versatility and vision.

FAMILY BACKGROUND AND EARLY EDUCATION

Ajit Kumar Saha was born on 31st August 1922 in Calcutta. His illustrious father, Meghnad Saha, needs no introduction. It is needless to mention that Ajit inherited many of his qualities from his father. His mother, Sm Radha Rani Saha, was a very devoted and kind housewife. In fact, her kindliness and genuine simplicity of character had won for her the affection and respect of generations of students and admirers of his father and colleagues of Ajit. Ajit was the eldest among the three brothers and four sisters.

His father, Meghnad Saha, joined the Allahabad University and hence Ajit spent his early years at Allahabad. He received his school education at the Anglo Bengali Intermediate College, Allahabad and passed the Matriculation Examination of the UP Board in 1935 at the age of 12 years. Subsequently he accompanied his father in a tour of the middle east and visited many famous places of antiquity. This travel left a deep impression on his mind. At the end of the tour, he studied for some time at the School of Paul Gehebe in Switzerland. On his return, he joined the Ewing Christian College at Allahabad and from there received the Intermediate Science degree of the UP Board in 1938. Thereafter Ajit joined the Presidency College, Calcutta and did his BSc degree with honours in Mathematics. He did his MSc degree in Pure Physics at the University College of Science, Calcutta University in 1942. His was the first batch of MSc students who were offered by the University a course in Nuclear Physics. His MSc thesis was on the Libby counter. His research career started in the Palit Laboratory of Physics of the University of Calcutta and under the guidance of his father, Prof Meghnad Saha. In 1945 he was awarded the Premchand Roychand Studentship (PRS) by the University of Cal-

cutta. On the basis of his thesis on a topic of nuclear spectroscopy, he was awarded the DSc degree by the University of Calcutta in 1946. In 1951 he was married to Sm Biswabani Saha.

Professional Career and Scientific Contributions

Ajit Kumar Saha worked for some time as assistant to the Palit Professor of Physics at the Pure Physics Department of the Calcutta University and subsequently in 1946 received a Junior Research Fellowship of the National Institute of Science (now Indian National Science Academy). He then left for England, was awarded the 1951 Exhibition Scholarship and worked at the University of Edinburgh from 1947 till 1950 in the laboratory of Professor N Feather. During his stay abroad, he visited the laboratories of Professor Scherrer at ETH Zurich, Professor K Siegbahn at Nobel Institute, Stockholm and Professor Madamme Irene Curie-Joliot in Paris. After his return to India, he was awarded the Mowat Medal of the University of Calcutta. He received offers of service both from the Tata Institute of Fundamental Research, Bombay and the Institute of Nuclear Physics, Calcutta. He joined the latter Institute in Calcutta as Reader. Subsequently in 1956 he became a Professor and then in 1968 a Senior Professor of this Institute. He served the Institute (which was later named as Saha Institute of Nuclear Physics in commemoration of the name of Meghnad Saha, his father, who founded the institute) till his date of superannuation. Ajit Kumar Saha played a significant role in the development of this Institute and worked as Director of the Institute for a short period around 1980. After his superannuation, he was appointed Emeritus Professor by the Institute for the rest of his life.

Prof AK Saha and the School he built up in Saha Institute of Nuclear Physics made many pioneering contributions in India in many areas of Physics. Nuclear Spectroscopy and Nuclear Magnetic Resonance (NMR) researches were initiated under his leadership. He laid almost equal emphasis on the theoretical and experimental aspects of research in physics. Prof Saha further emphasised the need for design and construction of new instruments in accordance with the research requirements. Around 1956-57, two major NMR equipments, one being of the continuous wave kind (both Block and Purcell types) and the other of a pulsed variety (Hahn type) were built. The groups led by him utilised these instruments in the study of the phenomenology of NMR, which stimulated variety of theoretical analysis in molecular quantum mechanics and statistical mechanics. This group also investigated in detail the problem of interpreting the complex high resolution NMR spectra by using the properties of crystal and magnetic symmetry groups. A book entitled 'Nuclear Induction' was published by the Institute under the authorship of AK Saha and TP Das, one of his students. After the initial developments were achieved, one commercial wideline (2-16 MH_Z) and one high resolution NMR spectrometer (100 MH_Z for proton) with suitable electromagnets were installed. The wide line spectrometer

enabled the group to undertake many interesting studies including i) charge-transfer mechanisms in molecules, ii) transferred hyperfine interactions in a series of rare-earth phosphates and vanadates, iii) elucidation of nature of ion-solvent interaction etc... Further to these works, a pure nuclear quadrupole resonance spectrometer (NQR) (30 MH_Z) and an electron paramagnetic resonance (EPR) spectrometer (X-band) were built in the laboratory under his supervision and encouragement. Mapping the details of nuclear quadrupole couplings and asymmetry parameters in several single crystals, delineation of the magnetic interactions in several copper complexes, theoretical calculations of EPR relaxation times etc. were some of the interesting lines of research that resulted thereafter. Researches on nuclear spin-phonon interactions in metals and acoustic NMR were initiated. A pulse-echo apparatus (10 MH_Z) and a continuous wave acoustic spectrometer (10 MH_Z) were built in the laboratory. Prof Saha had given a method of determining the orientation parameters of the electric field gradient tensor from a rotation study of the nuclear quadrupole resonance (NQR) spectrum.

After 1956, the group led by Prof Saha continuously expanded and newer areas of research were undertaken. A team of investigators emerged who developed the expertise on radio frequency and microwave techniques. He provided the necessary impetus and guidance in the building of a Stark-modulated microwave spectrometer (8-50 GH_Z). Subsequently a K-band gaseous microwave spectrometer with 100 KH_Z square wave modulation was set up. The microwave group made subsequently many interesting studies on several halogen substituted benzene and pyridine compounds. Prof Saha also initiated researches involving Mössbauer Spectroscopy, cryogenic research including study of acoustic resonance at liquid helium temperature, crystal growth and X-ray crystallography.

In the area of Experimental Nuclear Physics, the institute witnessed many significant developments and achievements under Prof Saha's leadership. The beta-gamma spectroscopy laboratory was born around 1952 where initially theoretical and experimental investigations in beta and gamma ray spectroscopy and in nuclear structure were undertaken. A short lens beta spectrometer with a continuous baffle was designed and constructed with a view to making precision measurement of beta spectrum and internal conversion coefficients. Being encouraged by the initial success and also for making scope for more advanced research, a high transmission Siegbahn-Slatis beta ray spectrometer was acquired for this group in 1957.

Experimental arrangement for the measurement of gamma-gamma directional correlation was set up. Initially scintillation counters containing organic phosphors were used. The need for using inorganic phosphors like NaI (T1), $CdWO_4$, $CaWO_4$ etc for having better response was felt and a project for building a Verneuil furnace was undertaken under his guidance to prepare these phosphors. The development of scintillation counting, coincidence spectroscopy and life time measurement had since then been pursued by the group with increasing degree of sophistication and many successful and pioneeering contributions were recorded. Measurements of life time of nuclear isomeric levels as low as 10^{-11} second and of gamma-gamma angular correlation

were achieved. The beta-gamma spectroscopy laboratory developed under his guidance has made a distinct contribution to the development of nuclear instrumentation in the institute.

Under his guidance the beta-gamma ray group developed a tradition of theoretical work on structural models relevant to their own experiments and also of broader interests. Theoretical shell structure calculations were continued. Also in the solid state physics area, students were trained and engaged in theoretical calculations of line widths, crystalline fields and other aspects of solid state theory. Another group was engaged in calculating accurate electron wave functions in light atoms not only in ground state but also in their excited states.

Prof Saha provided all through his scientific career a very fruitful, active and distinctive leadership toward the initiation and development of research, teaching and developmental activities in diverse areas in Saha Institute of Nuclear Physics. It may be mentioned that some of the instruments that were designed and fabricated by his group, *viz,* short magnetic lens beta spectrometer, spin-echo magnetic resonance spectrometer, NQR spectrometer with a special goniometer for rotation studies with crystals etc, were the first of their kinds made in India. Two separate divisions, Theoretical Nuclear Physics and Crystallography and Molecular Biology, emerged out of the expanding activities of his group. Besides, the investigators in his group formed the core of two other divisions, Solid State and Molecular Physics and the Experimental Nuclear Physics divisions of the Institute. A large number of students obtained the PhD degree under his guidance. Some of his students are now in the forefront of researches in their respective fields. The post MSc teaching course offered by the institute to bridge the gap between university education and research level was originally planned and organised by him. Prof Saha's advice and guidance were freely available to research workers of many different areas. The interest and well being of the institute was so dear to him that he sacrificed his personal career to a great extent. In fact he did not accept many coveted offers that came his way for the simple reason that he wanted to serve the Saha Institute as much and as best as possible. Indeed he had no hankering for top administrative position, the Directorship, of the institute. Had he wished he could have been the Director of the Institute long ago. The academic and scientific interests prevailed over any choice for administrative position.

Organisational and Extra Curricular Activities

During the later part of his life Prof Saha devoted himself to a thorough and analytical study of the energy problems that mankind in general is likely to face and in particular the energy problems of developing countries including India. How the energy problems would affect India was the subject for the focal theme of the 67th session (1980) of the Indian Science Congress of which he was the General President. As General President,

he recorded extensive observations, recommendations and comments on the energy strategies for India in the days to come. Moreover, as a Member of the Indian delegation to the Sri Lanka Science Congress held in 1968 he extensively dealt with, in his address, the problems and prospects for development and utilization of nuclear energy in developing countries. He rightly pointed out that the energy crisis cannot be met if India's population is allowed to increase unchecked. He made a quantitative study of the present status of energy resources including i) fossil fuels, ii) oil, iii) natural gas, iv) hydroenergy, v) nuclear fuels, vi) biomass, and vii) solar energy and analysed the status, including the production capacity and efficiency, of energy from various sources. Some of the important recommendations that he put forward included that i) energy planning should occupy the position of highest importance when planning the national economy, ii) there should be a central data bank for storage of energy data of the country as well as of other countries, iii) it will be necessary to conduct vigorous prospecting for new sources of energy, iv) production of ethanol from biomass for transport fuel is assuming importance all over the world and should be actively considered by the energy policy framers, v) in the matter of production of electricity, installation of oil based thermal generation stations must taper off with time and more and more dependance on coal has to be envisaged, vi) a major role in the production of electricity in the coming years will have to be played by hydel systems, vii) vigorous prospecting for uranium is required for further development of India's nuclear energy programme etc. While considering the prospects of new energy sources, he pointed out that solar energy being a continuous source of energy but of very low quality, conversion technology has to be improved significantly to convert it to a form of high quality like electricity. He anticipated that hydrogen will possibly be the most widely used fuel in future. He further recommended that fuel cells having many desirable features *viz,* absence of moving parts, high efficiencies, usability on the modular principle etc, should demand significant attention of energy planners. While considering the energy problems of future, Prof Saha was equally aware of the environmental pollution problems and social aspects of energy production. In short, Prof Saha had exhibited through his addresses and writings profound depth of knowledge of the problems and prospects of energy production.

Professor Saha acted as Chairman of the Cyclone Review Committee set up by the Department of Science and Technology, Government of India in 1979 and submitted a comprehensive report in May 1984. This report reviewed the Cyclone Monitoring and Cyclone Waring systems as they were being pursued in India and presented valuable suggestions for a National Cyclone Code, a Cyclone Emergency Action Plan and a Community Preparedness plan against cyclones for the coastal states of the country. The 480-page voluminous report presented many important recommendations for consideration of i) the Indian Meteorological Department in respect of cyclone monitoring and warning systems, ii) the Government of India and coastal State Governments in respect of the National Cyclone Code, the Cyclone Emergency Action plan and the Community Preparedness plan against cyclones and iii) various research organizations in respect of research and training areas connected to cyclones. The other important

members of the committee included Dr SK Das, Director-General of Meteorology, Govt of India, Prof PK Das, Ex-Director-General of Meteorologyy and Dr AP Mitra, the then Director, National Physical Laboratory, New Delhi. This report was a significant contribution by Indian scientists toward a national cause.

Professor Saha had wide interest and significant knowledge in many areas of arts and science besides his own scientific researches. Part of this versatility he imbibed from his illustrious father and part he developed himself. He was a prolific reader of English literature and was conversant with the history of world and particularly the Greek History. Phonetics was one of his very favourite subject. Not only he was very fond of but also he could explain the intricacies and grammar of western music and also Indian classical music. His interest in Astronomy originated partly from the contributions of his father. In his Inaugural Address to the Seminar of Astronomy and Mathematics, organised jointly by the Indian Council for Philosophical Research and the Asiatic Society, he pointed out that Astronomy was perhaps the first science to be studied in a systematic way and that today there seems to be no ends to the surprises that the astronomical discoveries are bringing in. He appealed that we should open our mind beyond Surya-Siddhanta and the other Siddhantas, which recorded the early Indian Astronomical findings, to the ever expanding horizon of modern astronomy.

Honours And Association With Societies, National Committees and Organisation

Professor Saha had been the recipient of many distinctions and honours since his school days. He was awarded a gold medal for standing first in Bengali Examination at the Matriculation Examination of the UP Board in 1935. He stood third in order of merit at the Intermediate Science Examination in 1938. Also he stood third in order of merit at the MSc Pure Physics Examination of the Calcutta University in 1942. He received the Premchand Roychand Studentship (PRS) of the University of Calcutta in 1945. In 1951, he became the recipient of Exhibition Scholarship of the University of Edinburgh. He was elected Fellow of the Indian National Science Academy in 1959 and was the Honorary Fellow of the National Academy of Sciences, India.

Prof Saha was associated with many learned societies and organizations in various capacities. He served as i) member of the Council of the National Physical Laboratory, ii) Member of the Board and Governing Body of the Council of Scientific and Industrial Research (CSIR), iii) Member of the Council of the Indian Association for the Cultivation of Science, Calcutta, iv) Member of the Council, Bose Institute, Calcutta, v) Member of the Council for Meteorological and Atmospheric Sciences, vi) Member of the National Committee of Science and Technology set up by the Government of India, vii) Member of the Committee formed by the Government of India for investgating the nuclear device

placed on the Nanda Devi, viii) Chairman of the Cyclone Review Committee set up by the Government of India, ix) Member of a Scientific Delegation sent by the Government of India to USSR in 1958, x) Member of the State Almanac Committee set up by the Government of West Bengal in 1963, etc. In 1968, Prof Saha represented the Indian Science Congress Association at the Annual Meeting of the British Association for the Advancement of Science at Dundee and also the Annual Meeting of the Sri Lanka Association for the Advancement of Science. He served the Indian Science Congress Association for long time in various capacities, as General Secretary from 1966-1970, as Treasurer from 1971-1974 and again in 1976-1977 and as General President in 1980. He was a Founder Member of the Indian Biophysical Society and served the Society as Treasurer for many years. Prof Saha acted as Director of the Bose Institute in 1977 and subsequently of Saha Institute of Nuclear Physics in 1980.

Family and Personal Life

His family life was a happy and responsible one. By nature he was very calm, quiet and systematic and as such his father depended most on him. He took all pains right from his younger days to give appropriate relief to his father in respect of financial and other family matters. He was equally dutiful toward his younger brothers and sisters and did his best to spare them as much as possible from any sort of hardship. Meghnad Saha was indeed very proud of his eldest son, Ajit and often expressed to others about Ajit's proficiency in mathematics and other subjects. His mother was equally if not more confident about his ability and sense of responsibility. Although his wife, Sm. Biswabani Saha, came from a very rich family, she did not aspire for wealth and comfort, rather felt proud for the intellectual attainments and scientific contributions of her father-in-law and husband, and played the role of a devoted and efficient housewife.

Professor Saha is survived by his wife, a son, two daughters, two sons-in-law and a number of grand children. His son, Prabal, has been engaged in Pharmaceutical Machineries Marketing affairs. His daughter, Anamita, is married to Sri Amiya Baran Saha, who is an engineer and has been holding the post of Joint Director of the Department of Electronics, Government of India. His second daughter, Nandini, is married to Sri Prabir Mukherjee who is a Chartered Accountant and is holding the post of Manager of the Bank of Baroda. This well-knit family has lost a simple, loving and responsible husband and father.

Last Days

Prof Saha had been keeping a good health all through his life except for the last one year or so. He was suffering during this period from rectal cancer. Initially he was under the treatment and care of Dr Dipak Banerjee, a surgeon and urologist, who could diagnose the disease properly. Dr Banerjee suggested surgical removal of the rectum

particularly since the disease was till then localised and felt confident of his recovery thereby. Since the very name cancer is a dreaded one, the family sought other expert's views. Unfortunately the suggestion of Dr Banerjee was not accepted and Prof Saha was subjected to radiation therapy in a Cancer hospital in Calcutta. After going through a number of courses of radiation therapy, it appeared that the cancerous cells were killed and the patient had recovered. The Chief of the cancer hospital felt very confident about his recovery. Indeed, the patient, Prof Saha, himself felt very fit and so much so that he resumed his normal activities, attended meetings, visited places etc. Many of us who visited him during this time also had a glimpse of his recovery. He himself expressed to some of us that he was feeling confident that he would see the end of twentieth century. But alas ! that was not to be and this recovery was a very temporary one. He again fell seriously ill and had to be transferred to a nursing home. The illness, this time, was not due to cancer but because of massive damage of kidney and all surrounding tissues. The kidney did not function at all. This was totally unexpected and it was felt by the attending physicians and others that such an extensive damage resulted from a massive and non-localised dose of radiation to which his rectal part was exposed. The end came soon through a heart attack. It is no use now arguing about the cause of the extensive damage leading to death, but certainly the unanimous feeling was that his life could have been prolonged by many years by a carcful and appropriate medical treatment. On 1st March 1991, he left for his heavenly abode.

ACKNOWLEDGEMENT

I wish to offer my sincere thanks to Sm Biswabani Saha and Shri Prabal Kumar Saha, wife and son respectively of the late Professor Ajit Kumar Saha, for their kind cooperation and valuable help in providing many important and factual data on the life and works of Professor Saha. Thanks are due to the Indian Science Congress Association for making available to me important materials about the works of Professor Saha and his association with ISCA. Thanks are also due to many individuals who helped in the writing of this memoirs through personal discussions.

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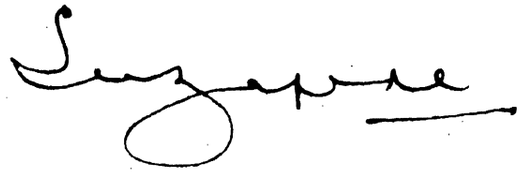

SYED MUZAFFAR ALI

(1909-1966)

Elected Fellow 1960

BIRTH AND EDUCATION

SYED MUZAFFAR ALI was born in Agra in Uttar Pradesh on October 10, 1909. His father, Syed Rahmat Ali, was Office Superintendent in the British Army and after retirement he settled down at Agra on account of his land property there. Rahmat Ali had two sons and one daughter. Muzaffar Ali was the younger son. His elder brother Syed Zafar Ali, after having graduated from Agra University, joined the postal department and retired as Postmaster. The sister was younger than Muzaffar Ali. Ali's father was a man of average means but he was an enlightened person and wanted to give the best education to his children. From the very beginning Ali was very inquisitive and at school in Agra he endeared himself to all his teachers. Young Ali would not accept the solution of any problem unless he had fully understood it. Sometimes his teachers would frown upon him but he would not give way unless the phenomenon was analysed cogently before him.

For his higher education Ali entered into Agra College which enjoyed a great reputation for science subjects in those days and graduated from there in science subjects and finally took Master's degree in Mathematics from the Allahabad University in 1928 at the age of 19 years. In those days a French Mathematician Andra Vail was teaching mathematics at the University of Allahabad. Andra Vail was so much impressed by the brilliance of Muzaffar Ali that he invited Ali to work with him for his research degree in Mathematics. Had Andra Vail stayed at Allahabad, Muzaffar Ali would have been a mathematician than a geographer.

Andra Vail had to leave Allahabad soon and returned to France. Ali was so much depressed on the departure of Andra Vail that he left research in Mathematics and joined as lecturer in Mathematics in Islamia College, Peshawar and subsequently worked as Headmaster of Doon School for about a year. Later on he came to Aligarh and joined the post-graduate classes in Geography in 1933. In those days Aligarh Muslim University

was the only centre of postgraduate studies in Geography in the country. The university being nearer to his home town, offered added attraction. In 1935, Ali took his Masters degree in Geography from the Aligarh Muslim University.

Young Ali was married to Shaheda Begum on 30 December 1944 and had five sons and two daughters. He arranged higher education for all his sons and daughters. His eldest son Saeed Muzaffar is Professor and Dean of Linguistics, University of California. His second son, Masood Muzaffar Ali did his LLB and is Advocate at Sagar. His third son Mahmood Muzaffar Ali, completed his MSc in Zoology and at present is Technical Officer in Forensic Science Laboratory in Saugar University. Mansoor Muzaffar, is his fourth son, who has done his M Tech and works as Project Officer at Calcutta. Musheer Muzaffar, his fifth son, completed his M Pharm and is working as lecturer in Hamdard College of Pharmacy, University of Delhi.

His daugther Miss Rana Muzaffar Ali and Reshma Muzaffar Ali are highly educated. The former has done MA in Sociology and BEd, while the latter has completed her MD.

Professor Nafis Ahmad who subsequently became the Head of the Department of Geography, Dhaka University was his classmate at Aligarh. He has recalled in his reminiscences about Dr Ali in the following words : One day in the class I noticed a new intelligent looking, handsome fellow sitting not far from me. After the class somebody introduced the newcomer from Agra (already an MA in Mathematics) to me as Muzaffar Ali. He smiled warmly and since that day we struck an everlasting friendship. Muzaffar had always his sunny side up. He was full of zest for life and possessed a vibrating sense of humour. He was popular and respected among his classmates.

In 1937 Ali proceeded to UK for his PhD in Geography and joined research in the Berbeck college under the supervision of Professor EGR Taylor and in 1939 obtained the degree of PhD in Geography of the University of London on his thesis 'The Geographical Study of the Ghaggar Plain.'

Dr Ali had earlier been appointed as lecturer in Geography at the Aligarh Muslim University in 1935, and soon after his return from London occupied the position of Readership in the same Department. He acted as Head of the Geography Department of the Aligarh Muslim University from 1949-56. He joined the University of Saugar as Professor and Head of the Department of Geography which position he occupied till the end (December 1966).

Prof Ali will be ever remembered as an excellent teacher and a keen research supervisor. He had a great flair for teaching and research. He was a man of vision and while teaching the geography of landform, his description was so vivid and graphic and

his analysis so complete and clear that his students had not to read the subject twice. In fact he evinced full command over the subject which he taught and came to the class well prepared. He knew how to put across his ideas in order to bring them home to students. Prof Ali, with his clear expression and systematic thinking had evolved a unique method of teaching and it would be no exaggeration to say that students repented when they missed his class. It would not be out of place to mention a mental conflict which the writer had to undergo as his student in 1945. The writer was preparing for the Civil Services examination as an MA student. Ali's lectures were so fascinating that it was a hard decision to make whether or not to go to Allahabad from Aligarh for taking the competitive examination which would have taken about 3 weeks. Ultimately the writer decided in favour of attending the lectures and voted against taking the Civil Services Examinations.

Prof Ali always shunned thinking about geographical problems in the routine and stereo-typed manner. He usually came out with new ideas and wanted to develop new trends in geographical thought. In 1957 when he joined the University of Saugar as Professor and Head of the Department of Geography, he felt that the country needed practising geographers and he reshaped the Department as that of 'General and Applied Geography', the first of its kind in the country.

Prof Ali had an abiding interest in Arab Geography for which he studied Arabic and French and undertook the task of translating Reinaud's *Introduction generale a la Geographi d' Abulfeda tome* I Section II and III which contains a masterly exposition of the growth of Arab geographical ideas and the contributions of Arab Geographers to various branches of geography. Reinaud has been one of the leading French orientalists of the nineteenth century who made valuable researches on the geographical contributions of the Arabs, Persians and Indians in the Middle Ages. His works are invaluable for the researcher in oriental Geography, particularly that of the Arabs. For the Indian student, the greatest handicap is that of language as all his works are in French.

It was with this end that in 1947, Prof Ali undertook the translation of Reinaud's works. As Reinauds "Introduction" is a voluminous work, Prof Ali translated the first half of the book and got it published under the title 'Arab Geography'. Prof Ali translated the second half of the book which could not be published during his life time. Later the translation of Reinauds Part III of *Introduction generale a la geographic d' Abdulfeda tome* I, was published as *Arab Geographical Thought*. While translating, he was very meticulous to compare and verify the references from the texts and then compared the translation with the French text.

The annotations, comments and explanatory notes on the translation of Reinauds' work is a living monument of his critical analysis and creative style. In view of his abiding

interests in Arab Geography, he drew a comprehensive plan of research on individual geographers like Al–Khawarizmi, Al–Masudi, Ibne-Haikal, Al-Beruni, Ibne-Yunus, Ibne-Majid, and others. As the whole period from IX century to the XIV century was full of scholars of geography, Prof.Ali felt the need to conduct research in Arab Geography for each century separately. For this purpose he was in search for students with the background of Arabic and Mathematical Geography, so that the contributions of Arabs to Mathematical Geography and cartography could be properly assessed and evaluated. In the later years of his life, he took up seriously the study of Sanskrit which finally resulted in his publication of the *Geography of the Puranas*, easily the best book on the subject, in which without sacrificing scientific austerity he has made the book interesting and instructive. The book incidentally has also opened up a new venue for the younger generation. A great savant with an abiding faith in God and Islam, extremely religious in his personal life, he demonstrated by his close and careful study of the great Hindu epics, the universal brotherhood of man and the need for love, toleration and understanding among the peoples of different religious faiths and beliefs in India, indeed something well worthy of emulation. In so far as the interpretations of various geographical texts of the Puranas are concerened, Prof Ali took necessary precautions. His close study of the present day physical geography of India and contiguous external regions has helped him in correctly locating various place names. The identifications of mountain MERO or SUMERU of the Puranas with the Pamirs as suggested by Professor Ali is amply convincing. He located some of the geographical names given in the Puranas in the various Himalayan regions and in Afghanistan. It is interesting to note that the names of some of the rivers, lakes, janapadas and towns of those regions were later on made current in several parts of India. The migration of names continued for a long period. It did not stop within the limits of Indian territory. The tradition was carried to Burma, Ceylon, Indo-China and Indonesia, and a large number of names of the janapadas, towns and rivers found in Indo-China and Indonesia bear testimony to this. In identifying the various names, Professor Ali took help from the topographical survey maps and the accounts of various foreign writers who visited India from time to time. In so far as the interpretation of various geographical texts of the Puranas are concerned, he took into account the different readings pertaining to the geographical details in various Puranas. Some of the texts are ambiguous. Professor Ali sifted carefully the geographical matter of Vayu Purana. The doubtful problems of the text were compared by him with the relevant matter occurring in the other Puranas and care was taken to maintain the real sense of the original text.

Besides astronomy and cartography, historical geography and regional geography, surveying and geomorphology were his other interests. He not only introduced advanced surveying as part of the practical course at the postgraduate level at Saugar, but emphasised the need for a survey project. He got prepared large scale maps of the excavation

site at Eran (Sagar district, Madhya Pradesh) and a large scale plan of the Nepal Palace Area at Sagar. He personally supervised the preparation of the plan of Palace Area.

Prof Ali had the vision to foresee powerful emerging currents and he did not hesitate to modify his conceptual and methodological framework to accommodate them. This vision and resilience helped him to emerge as leader in Indian Geography. He built up university departments and trained a dedicated band of geographers. His research work in the thirties on 'Population and Settlement Geography of Ghaggar Plain' is still regarded as a standard reference in the subject and his single article on the subject published in the *Indian Geographical Journal* has inspired many subsequent scholars to undertake research work in this important field. The article traces the growth of population and settlement in a strategically located region of the sub-continent, the Indo-gangetic watershed comprising the Ghaggar and the invisible river Saraswati. The pressure of population pushed the centre of civilization farther and farther eastwards, resulting in the reduction of the Ghaggar plain to the status of a corridor, a melting pot of races. Prof Ali succeeded in highlighting the role of the historical processes in evolving an intricate pattern of population groups and centres composed of a base of typical Aryan tribal with superimposed elements of subsequent civilization.

Prof Ali had a keen interest in cartography. He was never satisfied with the conventional methods of cartographic representation of data and evolved new methods for a proper appraisal of the distribution of population data.

Prof Ali possessed a thorough insight in surveying. His essay 'Single point Plane-Tabling' shows his grasp in surveying. He has suggested a simple device wherein the survey can be done with reasonable accuracy with one point instead of the conventional two points. The equipment required by single point plane-tabling is the same as for ordinary plane-tabling except for a special alidade which Prof Ali himself designed. The method was applied in surveying a small area at Sagar. In fact the area was surveyed in less than half the time of that of ordinary plane table and the result was reasonably accurate.

Prof Ali's keen interest and scientific insight into the subject was well recognized when in 1960 he was elected a Fellow of the National Institute of Sciences of India (now known as the Indian National Science Academy) being the first geographer to be elected. He presented a paper 'Geography in Ancient India' at the NISI Symposium on History of Science in Ancient and Medieval India held in 1961 at the Academy in his capacity as a Fellow of the Institute. His paper 'Human Geography of the Indian Desert' which he presented at a seminar on Arid Zone Research at Jodhpur was widely acclaimed. His last academic activity was his presentation of a paper 'Contribution of Geography to River Basin Planning' at the symposium on 'Role of River Valley Projects in National

Planning' at New Delhi in 1966 where he emphasised the task of geographers in integrating land and water resources and highlighted his concept of Applied Geography.

It is rather uncommon to 'come across an eminent scholar who is also a very able administrator. Prof Ali combined in himself both the qualities. While at Aligarh he was the Provost of a hall of residence of students, Captain in the National Cadet Corps, and was in-charge of Military Science teaching in the University. At Sagar he was Chairman of the University Delegacy in which capacity he arranged for the opening of a Delegacy Centre in Sagar City. He was also for some time Treasurer of the World University Service.

Membership to Societies

Prof Ali served as President of the Indian Council of Geographers, Vice-president of the Indian Geographical Society (Madras), member of the State Advisory Board for the revision of Gazetteers of Madhya Pardesh and also of Uttar Pradesh, and member in the Expert Advisory Committee in Geography of the Commission for Scientific and Technical Terminology (Government of India).

Prof Ali gave and received complete cooperation from his colleagues both at Aligarh and at Sagar. His colleagues gave him complete personal loyalty and he won their support by his gentle manners, affection and kindness. In his insistence on high academic standard he got ready appreciation from colleagues both in geography and other subjects. Dr Ali left for New Delhi on December 25, 1966 only never to return to Sagar. After a sudden stroke occurred in the early hours of December 30, 1966, exactly the same date on which he was married in 1944, he was removed to hospital where he breathed his last in the evening of the same day. Prof Ali breathed his last in harness and his death was widely mourned in the country.

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ANIL KUMAR DAS

(1902 - 1961)

Elected Fellow 1943

BIRTH AND FAMILY

ANIL KUMAR DAS was born in February 1902 in a village in undivided Bengal. As birth registration was not common in those days, proof of birth-date used to be the matriculation certificate, which sometimes became the only document proving the holder's age. In Bengal, this was issued by the Calcutta University, which counted only completed months. As a result of this practice, many persons used to have their official birth date as the first of a month. In all probabilities, Anil Kumar Das birth date was thus fixed as the first of February 1902.

Anil Kumar's ancestral home was in a village called Harop, under the Police Station at Bagnan. The village was under Hooghly district at that time, but later, after reorganization brought under Howrah district. The Das family was among the original inhabitants of this village. The profession followed in the family in ancient times was that of village-barber; but Anil Kumar's grandfather made successful efforts to break-away from the old ways. He had his sons properly educated, and they all prospered in their new profession. The eldest, Priyo Nath, had become a toll-collector, the second son Pyari Mohan chose the profession of a contractor and the youngest, Debendra Nath qualified himself as a Civil Engineer. Debendra Nath took up the job of an engineer in the provincial service of Bengal and had to spend his life away from his native village.

Debendra Nath was married to Sarojini, a daughter of the progressive Pal family of Chinsura. Sarojini's education was informal, but she was well versed in English, and could read and write in that language. Their only child, Anil Kumar was born in Chinsura, in his mother's paternal home.

Anil Kumar Das spent his early childhood in Chuadanga in the Kusthia District of undivided Bengal (now in Bangladesh), where his father was posted. He was a student of Chuadanga High School, where along with his curricular activities, he took keen interest in sports. He was particularly skilled in swimming and in football. His active interest in football continued till his college days; he was the captain of the Presidency College football team during 1923-24.

Das passed his matriculation examination from Chuadanga in 1918 and joined the Berhampore College in Murshidabad of Bengal. In the meanwhile his father had his house constructed at Chinsura. In 1920, he passed his ISc Examination and joined the Presidency College, Calcutta, where he stayed in the college hostel. He lost his father a few months before his BSc Examination. In 1922, he passed his BSc with honours in Physics. He continued his post graduate education in the same college. Among his teachers here, Prasanta Chandra Mahalanobis, Charuchandra Bhattacharyya and Snehamoy Dutta were all well known for their roles in developing scientific temper among the students. In 1924, Das obtained his MSc degree in Physics and secured a first class in this examination, a feat which was quite difficult in those days. He topped the list of successful candidates and won the University Gold Medal.

Early twenties was the time when spectacular advances were being achieved in the field of spectroscopy and astrophysics, and Indian scientiests were playing pivotal roles. In Calcutta, MN Saha had just expounded his theory of stellar spectra connecting thermal ionization with the radio active processes occurring in their outer layers ; CV Raman's researches were opening up new frontiers in spectroscopy; Das decided to devote himself completely in scientific research in these areas. But the facilities available for post graduate studies to those fields in India were limited; he had no choice other than going abroad and studying in a foreign university. Scholarships or study grants were few and far-between, and Das could not secure any help. He sold his house in Chinsura, and with that money sailed to France in 1925.

He enrolled himself as a student of the University of Paris. He joined Prof Ch Fabry's group in Laboratorie de Physique and started working in spectroscopy. In 1926 he completed his dissertation on the *Studies in the Absorption Spectra of Halogens* and was awarded the degree of Doctor of Sciences by the University. For the next two years, Dr Das worked with Prof Max Born at the Institute fur Theoretische Physik and with Prof Augenheister at the Geophysicalishes Institut, Gottingen, and then spent a brief period at the Solar Physics Observatory at Cambridge, England. During his stay in Europe, he came in contact with many physicists and astronomers, and maintained a life-long association with many of them. His interest in astrophysics, particularly about the new enigmatic radiation, the cosmic rays was kindled during this period.

Das returned to India and joined the Indian Meteorological Service as an Assistant Meteorologist in March 1930. He was posted at Poona for a short period, then transferred to the meteorological office at Alipore, Calcutta, where he remained posted for the next four years. His main official work was meteorological forecasting, which he carried out creditably. But this was not enough to satisfy his scientific zeal; he published several papers giving some new ideas in meteorological measurements. These were the preradiosonde days before wireless communication became an easy method for remote sensing. He devised instruments with pellets of sulphuric acid inside glass helical tubes, which could be hung from hydrogen filled balloons. On reaching pre-set heights, explosive mixtures would be ignited by the sulphuric acid and the flash could be observed from

ground. Such instruments were fabricated and flown, and Das used the collected data in understanding several features of weather phenomena. But his interest spread much wider; unexplained topics in nature intrigued him. During this period he wrote a long article dealing with seismology and volcanic activity, which was published in the *Calcutta Review,* in its April 1934 issue.

In September 1934, Das obtained a year's leave and proceeded to England. He spent this period at the Solar Physics Observatory, Cambridge working with Prof FJM Stratton on spectrophotometric investigations of the temperature of the solar surface. Later he continued this line of work at Kodaikanal.

On return from leave, Das was posted to the Upper Air Observatory in Agra. This was the centre of the Meteorological Department for investigations in upper air currents and temperatures which needed among many other facilities, the use of hydrogen filled balloons. The facilities here, were sought by top scientists of the time including Millikan and Compton for cosmic ray studies; the observatory had among their staff, some members who had participated in their exciting experiments in India. Das did not have elaborate resources for conducting all experiments, but with his characteristic energy and enthusiasm, started regular observations on cosmic ray intensities. Later he continued his systematic investigations at Kodaikanal. In 1940, he published a paper entitled *Measurements of Cosmic Rays at Agra and Kodaikanal;* this was the first account of regular measurements at two places situated in different latitudes as well as in altitude. He attempted to correlate variations in cosmic ray intensities with solar activity in this paper.

In 1938, Dr Royds retired as Director, Kodaikanal Observatory, and Dr AL Narayana succeeded him. His vacant place was filled up by Das on transfer from Agra. From September 1937 to June 1942, he was posted as Assistant Director of this Observatory. During this period, he published a series of papers on solar prominences and motion of gases in the solar atmosphere. In a statistical analysis of 14 years' data, he showed that the area of calcium prominences was maximum in January and minimum in July. It is well known that the earth in its orbital passage comes closest to the sun in January; Das argued that the increased gravitational attraction on the sun is responsible for the increase in the area of the prominences. This increase was found to vary in accordance with an approximate inverse cube law, in relation to the sun-earth distance. In a series of papers on *The Motion of Gases in the Sun's Atmosphere* published in the *Indian Journal of Physics* during the years 1940 to 1942, Das attempted to work out a unified theory based on simple particle dynamics to explain many of the enigmatic behaviours of solar phenomena. All these happened a few years before Hannes Alfven developed the theory of magnetohydrodynamics which was able to account for most of the observed solar phenomena on the basis of a new concept. The same theory based on particle dynamics was later extended to explain the behaviour of sunspots.

In 1941, Edlen's famous work proved that the most prominent coronal emission lines are due to highly stripped heavy atoms. No explanation of generation of those highly

ionized heavy atoms existed at that time; Das readily forwarded a hypothesis based on ejection of particles from the core. Years later, alternate hypotheses appeared to explain the phenomena better.

When World War II broke out in India, Das was posted outside Kodaikanal, where he did meteorological work for the war operations. After the end of the war, he was posted back to Kodaikanal in early 1946. In July 1946, he was appointed as the Director of Kodaikanal Observatory. In the meanwhile a very important event in the history of astronomy took place in India. A committee for the planning of post war development of astronomy and astrophysics in India was appointed in 1945 by the Imperial Government; the committee consisted of several scientists and was chaired by Prof MN Saha. The committee remarked "On account of the restricted nature of activities Kodaikanal Observatory has not grown and kept pace with development of new knowledge and fundamental discoveries in astrophysics, and our considered view is that in consideration of its excellent location for astrophysical work and the very good work done by the institution in the past, immediate steps should be taken for its development".

Das stepped in at this stage; he strove hard steadfastly to organize and develop an astrophysical observatory at Kodaikanal equipped with the most uptodate instruments for work on the frontiers of astronomy. He established a small modern workshop and trained young persons in the construction of instruments for astrophysical research. To quote the words of Das, "These efforts were so successful that within a very few years it became possible to build locally at an insignificnt cost quite a number of perfectly satisfactory instruments of solar research, such as high dispersion spectrographs, coelostats, siderostats, photoelectric photometers and variety of other physical apparatus which made the daily routine work, as well as the investigational work of the observatory far quicker and more convenient than before". While concentrating on this instrumentation development, he kept up his scientific contributions and guided a number of research workers in the field of astrophysics, geomagnetism, ionosphere, cosmic rays and other allied subjects.

The observatory hill at Kodaikanal is situated at the geographical latitude of 10° 14′N and a geomagnetic latitude of 0.6° has several advantages for astrophysical and geophysical work. Almost a total coverage of southern skies is possible from this latitude, and almost horizontal geomagnetic lines of force impart some peculiarities in the behaviour of the ionosphere overhead. Das foresaw enormous advantage of simultaneous investigations of geomagnetism, ionosphere and solar activity and discovered the links between them.

A geomagnetic observatory was established in 1948. In 1951 a C-3, CRPL automatic vertical ionospheric recorder was installed. Many new characteristics of equatorial ionsophere were unfolded by these instruments. The C-3 ionosonde is still in operation, almost forty years after its installation and has collected invaluable data, a unique collection in the world. The magnetometers here have recorded violent fluctuations during many a magnetic storm, from which some insights into the nature of particle precipitation from

the magnetosphere has been obtained. Both the ionosonde and magnetic records have established subtle links between the activity on the sun and reactions on the earth's outer atmosphere. In fact, in a series of papers from Kodaikanal Observatory, a few years after the death of Das, solar X-ray fluxes were estimated from ionospheric data. But in the early fifties, such possibilities could be visualised only by a few persons with extra-ordinary foresight.

Das organized a division of 'Radio Astronomy' at the Kodaikanal Observatory. In fact, he was the leader of the team which started first radio observations of the sun in India. Two 'radio telescopes' in 100 and 200 MHz, consisting of a pair of Yagi antennas each and separated by a baseline of a few wavelengths formed two interferometers. Transit of the sun across their beams resulted in fluctuating intensity records on chart recorders. The same instrument could detect radio signals from strong sources like Cygnus and Cassiopeia.

The Stellar Physics divisions was already in existence with an 8 inch refractor under regular operation. An old 20 inch telescope from Poona Observatory was also available with them. Das extensively modified these instruments and adapted them to suit new experiments he planned. He joined the International Mars Observation Program 1954-55 and used the telescopes to photograph the martian disc during its close approach.

There were recommendations in the Saha committee report for creation of a central observatory with large aperture telescopes. Das made plans to create such an observatory with a 100 inch telescope and 46/34 inch Schmidt Cassegrain telescope. The instruments were very expensive and Das could not get funds for acquiring these. Much later, Vainu Bappu could obtain funds for indigenously fabricating a 93 inch telescope.

Das however managed to equip the Solar Physics group at Kodaikanal with most modern equipment. This division was already equipped with a fair number of optical telescopes and spectrographs, including both H-alpha spectrohelioscope and K and H-alpha spectroheliographs. But new and more powerful equipment were lacking; he took upon himself the construction of a large solar telescope combined with a powerful spectrograph of exceptionally high dispersive and resolving powers. It consists of a coelostat with three fused silica mirrors of 60 cm aperture and two telescope objectives of 37.5 and 20cm apertures. The primary and secondary mirrors of the coelostat are mounted on a double walled stone masonry tower of 11 meter height above ground and are so arranged that a broad beam of sunlight can always be reflected vertically downwards; the third mirror of this coelostat system (mounted on the floor of the tunnel) reflects the light horizontally into an underground tunnel of about 70 meter length. This long tunnel houses the telescope objectives and mirrors mounted on long horizontal steel rails and an exceptionally powerful 20 meter long spectrograph having both a reflection grating and a system of prisms as its alternate dispersive elements. The instrument incorporates every desirable feature useful for solar research. The design, construction and installation of the equipment required very thoughful planning, foresight, energy and determination,

and Das poured his body and soul for creation of this telescope. The equipment was fully ready for operation just a few months before he retired from service at the Kodaikanal Observatory.

One more ambitious project was started by Das, which could only be partly completed. Das wanted a coronograph to be installed at Kodaikanal. Corona and coronal streamers have fascinated the common men and astronomers equally, ever since they were seen at the time of solar eclipses. But there existed no methods of investigation of these except during total solar eclipses and even on those rare occasions the chance of success lay on the mercy of the weather. By moving all over the world, undertaking most hazardous journeys, the maximum total time one could get was about one hour in 25 years. Prof Bernard Lyot wanted a way out of this impass; he designed and built a telescope with very little scattering, where the brilliant disc of the sun could be occulted and one can study solar corona outside eclipses. Das lost on time in arranging for a coronograph at Kodaikanal. Through his persistent efforts and personal contacts he had the coronograph of 20cm aperture built by the associated and co-workers of Prof Lyot. He also obtained another of Lyot's inventions : the monochromatic heliograph. The main component of the instrument is a very narrow band interference polarising filter, incorporating a marvel of primitive electronic instrumentation. This instrument was installed and proved extremely useful. The coronograph, however, could not be put to optimum use, owing to unforeseen difficulties.

While engaged in large scale operations for developing and improving the observatory, Das kept up his scientific contributions and wrote a large number of papers. One of his outstanding contributions to solar physics was made in 1953 when he measured the temperature difference between the pole and equator of the sun. This provided an observational confirmation of the theory advanced by Bjerknes in 1926, that the sun is a baroclinic cosmic vortex in which angular velocity decreases with distance from the equatorial plane, which should result in a temperature increase at the poles. His observation also lent support to the thermodynamical theory of the origin of sunspots. Shortly before leaving Kodaikanal, he published another interesting paper in the Kodaikanal Observatory Bulletin, where he attempted to explain the origin and behaviour of sunspots and prominence from purely dynamical considerations. A large number of solar phenomena, including Evershed effect were satisfactorily explained in his simple theory.

Das organized an expedition to Iraq for making scientific observations during the total solar eclipse of February 25, 1952. The expedition, however, was not successful owing to vagaries of weather. He organized and sent a team of young scientists to Phalodi in Rajasthan to cover another eclipse on June 30, 1954, and then himself led a larger team to Ceylon next year. Although the circumstances of this eclipse were very favourable, he was again frustrated by overcast skies, and only managed to obtain some radio and geomagnetic observations during the eclipse.

As the Director of Kodaikanal Observatory and a leading astronomer of the country, Das went abroad a number of times. He attended the meeting of the General Assembly of the International Astronomical Union held in Rome in September 1952, and took the opportunity to visit the astronomical observatories in the continent at Arcetri (Florence), Zurich and Arosa (Switzerland), Potsdam, Paris and Meudon. He also visited the leading instrument factories at Cambridge, Oxford and London and the new Greenwich Observatory at Herstmonceux Castle. In 1955 he undertook another extensive tour. He attended the special symposium on Radio Astronomy organized by the IAU at Manchester, and then attended the Ninth General Assembly meeting at Dublin. On his way back, he went to the Crimean Observatory in USSR and attended a conference there on Physics of the Sun, Stars and Nebulae. He also visited other important astronomical observatories in Europe, UK and USSR before returning to India.

After retiring from Kodaikanal, Das went to the Ondrejov Observatory in Czechoslovakia in September 1960 and returned after about two months. This was his last visit abroad. Das always attempted to keep himself abreast of the development and discoveries in astrophysics; all of his foreign visits were aimed at this objective. He lost no time in translating these experiences into practice at Kodaikanal.

During his directorship at Kodaikanal Das refused, more than once, promotion as Deputy Director General of Observatories. There was no post of DDG at Kodaikanal and acceptance of promotion would have meant his leaving Kodaikanal. However, eventually, the Government of India created a post of DDG for him at Kodaikanal from March 1954. He was also granted an extension of service for 3 years from 1.2.57, beyond his normal age for superannuation.

After retirement from Kodaikanal Observatory, Das accepted the post of Director, Nizamiah Observatory and Professor of Astronomy, Osmania University in Hyderabad. A few months that he had here was mostly spent in planning the constructions at the new observatory near Japal-Rangapur village. The end came too suddenly. In February 1961, he was taken ill at Hyderabad and was removed to hospital, where a few days later, on 18th he breathed his last. Except for his new colleagues at the university, some of them being his old students at Kodaikanal, no other friends and relatives were present at the bedside. His faithful servant-boy, Velan, who was brought up by Das at Kodaikanal, looked after him in his last days; it was he who performed Das's last rites.

Personal Life

Das married Millicent in England in 1934, much against the wishes of his mother; they were known to each other from the days at laboratoire de Physique in Paris. She proved herself to be a very apt companion of Das, spending her entire life at Kodaikanal, encouraging him always in his creative work. Both Dr & Mrs Das were keen lovers of

dogs; they used to keep a large number of dogs at home and were keen dog-breeders. She, herself, was a well known social worker at Kodaikanal, being a member of the Skippo Van Committee for providing medical relief to the villagers around Kodaikanal. She organized a midday meal scheme in the primary school near the observatory. She was connected with the activities of the Sacred Heart College at Shenbaganur at the outskirts of Kodaikanal. Some of her personal collection of curios may be seen on display at the museum there. In 1959, towards the end of Das' service, she fell ill; diagnosis revealed it as cancer. She spent her last days at the Christian Medical College Hospital, Vellore. They had no children.

In his private life; Das was extremely helpful to anybody who sought his help and guidance. Anybody requesting for any data collected by the observatory was never disappointed. He was of a very helpful disposition, and privately he had many a time extended all kinds of assistance, including financial help, to many needy persons - whether it was for their children's education or for their maintenance. After his wife's death he drew up his will, bequeathing all his property to the Kodaikanal Observatory, for creation of a few scholarships in the memory of Mrs Das. To those who had come in close contact with Dr and Mrs Das, their demise has been the loss of a pair of kind and lovable hearts, who were always sought for help and consolation whenever needed.

Das had many qualities of head and heart. He was a hard task master and at the same time kind and considerate. He used to demand the best out of his colleagues and students; I have known the darkroom assistants at Kodaikanal Observatory taking meticulous care in preparation of chemicals; for they knew that the tiniest fluff on the developed plate will catch his eye. At the same time, he was always ready to roll up his sleeves and dirty his hands in difficult experiments. The amount of work which he himself had put in for the improvement of Kodaikanal is very large indeed. Das and his staff formed a compact team almost dedicated to the one great aim in view, namely to make Kodaikanal one of the foremost places of research.

Membership and Awards

Das was elected a Fellow of the Royal Astronomical Society in 1935. He was a Fellow of the National Institute of Sciences (now the Indian National Science Academy) being elected in 1943. In recognition of his distinguished services to the nation he was awarded Padmashri by the President of India on the Republic day of 1960. But the greatest recognition of his contribution to science was given by the International Astronomical Union in its 14th General Assembly at Brighton, England, when a newly discovered crater on the far side of the moon was named after him.

Das had a genuine and abiding affection for Kodaikanal. With a singular devoting to scientific research, he worked with untiring energy to build up a first class modern

institution. The task that Das undertook upon himself was completed to a major extent; his followers at Kodaikanal could bring out some new discoveries through instruments built by him. But he, himself, did not have the opportunity of working with the instruments set up through years of toil and strife, most of which were completed just before he left Kodaikanal. Das had one ambition in life which he had expressed on many occasions. He wanted to work at Kodaikanal during the last years of his life. In fact the assignment he took at Hyderabad was only for three years; thereafter, he wanted to proceed to Kodaikanal and had already written to the authorities for permission to this effect. But providence ordained otherwise, and he passed away within a year of his leaving Kodaikanal!

ACKNOWLEDGEMENT

The author gratefully acknowledges help from many quarters in completing this life-sketch. Details of his childhood and parentage were provided by Shri Dulal Chandra Pal, Teacher in the school at Dr Das's ancestral village; I express my grateful thanks to him. I am indebted to the Director-General, India Meteorological Department, Govt. of India, who had supplied bulk of the information about his service life. In writing this sketch, I have made free use of articles on Dr Das written by Prof SN Mitra, FNA and Sri S Basu, FNA, published in *Journal of Institution of Engineers of Telecommunication and Electronics* and *Journal of Meteorology & Geophysics,* respectively; I am indebted to both of them. I am thankful to Mr P Madhavan Nair, Kodaikanal, Prof KD Abhyankar, Hyderabad and Mr AP Jayarajan, Bangalore for their bits of information about Dr Das. Last, but not the least, I have picked up many bits of information from an unfinished manuscript by late Dr MKV Bappu, in which he attempted to write a complete life sketch of Dr AK Das.

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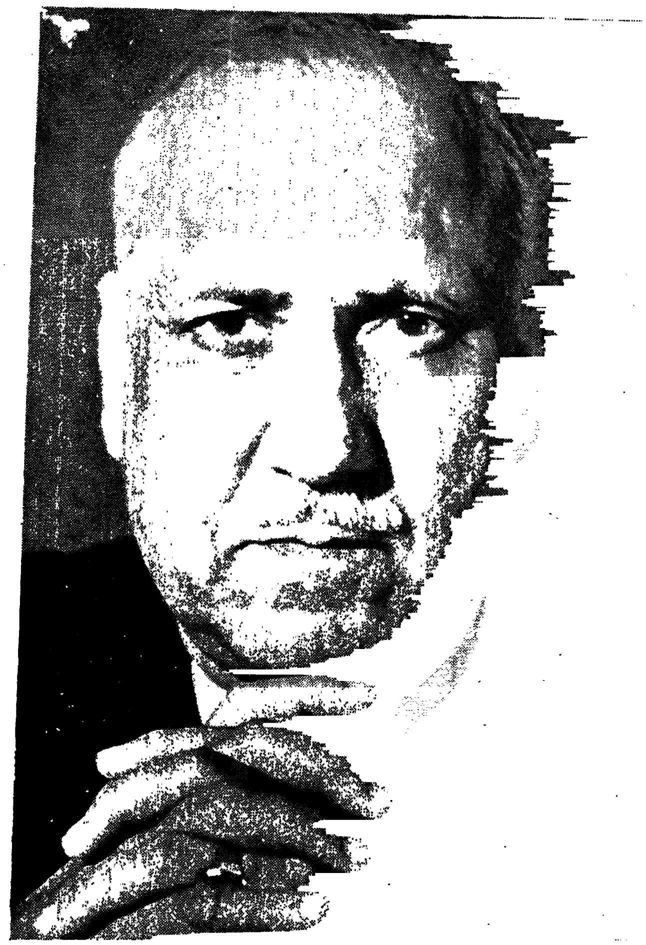

M.L. Roonwal

MITHAN LAL ROONWAL

(1908 - 1990)

Elected Fellow 1945

PRELUDE

In 1936-37, a new luminous star arose on the horizon of entomology which none could afford to ignore but gazed with an unprecedented admiration and wonder. This star was none other than MITHAN LAL ROONWAL, an Indian by birth.

Mithan Lal, at early age of 28 years, made epoch making fundamental contributions on the embryonic development of *Locusta migratoria migratorioides* R & F including the new theory of multiphased gastrulation in insects. Extensive summary of these work was included in the standard text-book, *viz. Embryology of Insects and Myriapods* by A Johannsen and FH Butt.

During my postgraduate studies I went through this book avidly and felt very proud to find the name of an Indian so reverentially mentioned in a text-book written by two eminent occidental scientists. When I was offered the post of a Research Assistant to the Forest Entomologist at the Forest Research Institute, Dehra Dun in 1951, I readily accepted it with a mixed feeling of joy and trepidation, as the Forest Entomologist was none other Dr ML Roonwal.

EARLY LIFE

On the 18th of September, 1908, a son was born in Jodhpur, Rajasthan to Mr Moolchand Roonwal and Mrs Jamna Devi. He was christened Mithan Lal by his loving parents. Geneology shows that his forefathers were artisans, farmers and soldiers of fortune under local chieftains. The family originally belonged to the tiny village Roon from which the family name Roonwal (belonging to Roon) was perhaps derived. The village Roon is situated in the district Nagour at the eastern fringe of the Thar, the great Indian Desert. The family migrated from the village Roon, a hundred miles South, to the village Narwar near Ajmer, then to Ajmer. Mithan Lal's father later shifted from Ajmer to Jodhpur when he took employment under the erstwhile Jodhpur Bikaner Railway. Mithan Lal had three sisters christened Nathi Bai, Mohini Bai and Rameswari Bai who were

younger to him. He maintained cordial and affectionate relations with all of them till he breathed his last. His sisters were naturally proud of the achievements of their celebrated brother.

EDUCATION

Mithan Lal had his schooling entirely in Jodhpur. His primary education started at Sri Pratap School, then he shifted to Sadar School and finally to Darbar High School from where he matriculated in 1924 with credit. His interest in the academic field was kindled at the Darbar High School. His early association with Sadar School which was later elevated to a Higher Secondary School continued unabated till his last breath. During the Diamond Jubilee Celebration of Sardar Higher Secondary School, Prof Roonwal not only sent a *Message* but also contributed an article on *Science education in school* which was published in the Diamond Jubillee volume (December 1972, actually published in 1974).

For his higher education, Mithan Lal shifted to Lucknow where he took admission in Lucknow Christian College. He passed his Intermediate in Science examination in 1926 creditably. He studied Physics, Chemistry, Biology, Hindi and English at the ISc Stage. He then studied in Lucknow University for his three years' (Hons.) examination which he passed in 1929. Late Prof. Karam Narain Bahl was the Head of the Department of Zoology at the Lucknow University who very much loved to take the undergraduate classes. Mithan Lal impressed Prof Bahl so much that he consented to be his supervisor for the thesis work during his MSc (Honours School) examination which he passed in 1930. His thesis was on the post-embryonic development of the respiratory system of *Dialeurodes dissimilis* Quaint & Baker. He Published a short account of his findings in the most prestigious journal *Nature,* London, in 1934. After obtaining the MSc (Honours School) degree, Mithan Lal took up employment as Research Assistant in the Locust Research Laboratory of the Imperial Council of Agricultural Research at the Punjab Agriculture College, Lyallpur (now in Pakistan) under Late Prof M Afzal Hussain. Early association with Prof Bahl and Prof Afzal Hussain proved a boon to the young Mithan Lal, as both of them were celebrated Zoologist and Entomologist at that time. Mithan Lal's association with Prof Bahl followed the age old *guru shishya parampara* (traditional teacher taught relation). Prof Bahl inspired him to go in for higher studies abroad which Mithan Lal did in 1933 when he was in residence at the Cambridge University, England. Late Dr AD Imms, FRS, was his guide for PhD Thesis. Incidentally, Prof Imms was Professor in Biology at Muir Central College, Allahabad University and the Forest Entomologist, Forest Research Institute, Dehra Dun before he took up employment at the University of Cambridge.

His earlier work with Indian Locust (*Schistocerca Gregaria* Forsk.) proved useful to him for his thesis work when he took up the studies on the embryology of *Locusta*

migratoria migratoroides R. & F. He was awarded the PhD degree in 1935. Subsequently, his *alma mater* conferred on him the highest degree in science, ScD, in 1967 on the strength of his published work.

Prof Roonwal's formative years in scientific pursuits have had the benefit of his close associations with a few brilliant minds in Zoology/Entomology at the time, like Late Prof KN Bahl., Late Prof M Afzal Hussain, Late Prof AD Imms and Late Dr Y Ramchandra Rao. These associations inculcated in him a sense of dedication, discipline, commitment to science and catholocity in reading habit which proved very rewarding in his later years.

During his service in the Zoological Survey of India, Dr Roonwal came in close contact with Dr Baini Prasad, DSc (Edin.), FNA, FRSE and Late Dr SL Hora, FNA both being very brilliant Zoologists on their own right. Dr Baini Prasad played no mean role in the career advancement of Dr Roonwal. The contact with Dr Baini Prasad was renewed when the latter decided to settle down in Dehra Dun after his retirement.

Marriage and Family Life

Mithan Lal was married at the early age of 16 to a 13 years old girl, Premvati, who hails from Ajmer. It was a traditionally arranged marriage. Mrs Premvati is a very pious, sweet tempered, homely, hospitable, thoughtful-for-others and affectionate lady with unassuming and retiring nature. They have four children, a son and three daughters. In addition, Dr and Mrs Roonwal brought up and fully supported a nephew (sister's son) whose father passed away when he was very young. He was brought up in the Roonwal's family like another son who even uses his uncle's surname (Roonwal). He is now a successful and distinguished academician in Geology in the University of Delhi. Dr Roonwal had very intimate family bondages and ties. Maintenance of kinship, an Indian tradition, always got priority in his life. His children (including the nephew) were receipient of his loving care, and abundant affection. He was not an interfering type in moulding their educational and service career, his disciplined nature and upbringing notwithstanding. However, he always kept a watchful eye on their habits and behaviour. Any departure from the norms would not go unnoticed. He would mildly reprimand the recalcitrant one with sweet and convincing reasonings without hurting their ego and innate self-respect. Dr Roonwal was thus a contended family man and gave enough attention to the family whatever time he could spare from his set routine. Family tradition demanded that all his children including the nephew should be hardy, honest, disciplined and industrious. His strict regime in the daily routine of family might not have been to the liking of all the members of the family but his towering personality brought about an atmosphere of cordiality and oneness among the various members of his family with varied tastes and likes and dislikes. To most of his family members, he was like a huge banyan tree providing soothing comfort to one and all who took shelter under it.

SERVICE CAREER

Prof Roonwal started his service career in a humble capacity soon after passing his MSc (Honours School) examination in 1931, as a Research Assistant in the Locust Research laboratory of the Imperial Council of Agricultural Research (renamed Indian Council of Agricultural Research) at the Punjab Agricultural College, Lyallpur under Late Prof Afzal Hussain who was himself an Entomologist of great repute and erudition. This early association in the field of locust and grasshopper science continued for a very long time (up to 1983) even after his dis-association from Locust Research Organisation in 1939.

On his return from Cambridge after obtaining the PhD degree, Prof Roonwal worked for a few months as the Assistant Professor and Head of the Department of Zoology at the Government College, Ajmer where he hardly could get facilities to carry out research. The job was professionally unsatisfactory and he rejoined the Locust Research Scheme of the Imperial Council of Agricultural Research as the Assistant Locust Entomologist and Officer-in-Charge, Locust Field Resarch Station at Pasni on the Baluchistan Coast. He served in this post for a period of 4 years (1935-1939). Here he came in close contact with Late Dr Y Ramchandra Rao who was designated as the Locust Research Entomologist to the Imperial Council of Agricultural Research.

In 1939, he was appointed as Officer-in-Charge, Bird and Mammal Section, Zoological Survey of India, Calcutta. He held this position for a period 10 years (1939-49). he reorganised the Section which later became one of Advanced Centres of taxonomic research on birds and mammals in India.

Dr Roonwal was selected as the Forest Entomologist and Chief Research Officer, Forest Research Institute and Colleges, Dehra Dun in 1949 and served in that capacity for a brief period of seven years. During his tenure as the Forest Entomologist, he made important contributions in the reorganisation of the Forest Entomology Branch, Forest Research Institute, Dehra Dun during the post-Independence period. He went to Chicago and other places to study termites on a FAO Fellowship. He brought with him a large collection of authentically identified termite species of the Oriental Region from the laboratory of Late Prof Alfred E Emerson, Department of Zoology, Chicago University, Chicao, USA. The collection also contained several cotypes and paratypes of oriental termites. He thus laid a solid foundation for termite research at the Forest Research Institute, Dehra Dun. He also procured several sophisticated equipment from USA as a gift under Indo-US Cooperation Mission. The present author has had the fortune in assisting Dr Roonwal in establishing a strong School of Termite Research at the Forest Research Institute and Colleges, Dehra Dun. On the foundation laid by Dr Roonwal arose a great edifice that covered all aspects of termite research in India and FRI and Colleges is now a centre of pilgrimage to the Termitologists of the world. Unfortunately,

FRI and Colleges, Dehra Dun could not give him a position higher than the Chief Research Officer on account of the service rules that were restrictive to the career advancement of forest scientists working there. Dr Roonwal strived his best to remove this shortcoming of the FRI and Colleges but was not successful.

Consequent to the realisation that FRI, Dehra Dun was not in a position to recognise and reward his outstanding scientific contributions, Dr Roonwal left FRI to take up the position of the Director, Zoological Survey of India, Calcutta, his parent organisation, in 1956, succeeding Late Dr Sunder Lal Hora who passed away in harness. Dr Roonwal served ZSI for nine years (July 1956 to Aug. 1965). He left ZSI prematurely on account of differences with higher ups in Delhi.

After leaving ZSI, Calcutta, Prof Roonwal joined the University of Jodhpur as Professor and Head, Department of Zoology (September 1965 Aug. 1966). He was appointed Vic-Chancellor of Jodhpur University in 1966 for a period of 3 years (Aug. 1966-Aug. 1969) when the university was facing considerable administrative and academic problems. University was lucky to have such an experienced and seasoned administrator in those critical days. After his retirement as the Vice-Chancellor, Jodhpur University, Prof Roonwal associated himself, till his passing away, with the Desert Regional Station of the Zoological Survey of India, Jodhpur. He was also appointed by the Council of Scientific and Industrial Research as an Emeritus Scientist (Aug. 1969-September 1973).

During the Second World War, Dr Roonwal was seconded to the Army and was given the rank of a Major in the 15th Punjab Regiment, South East Asia Command. He was posted in Assam-Burma War Theatre. His mandate was to study the mammalian hosts of the tsutsugamushi disease (scrub typhus) in the Assam-Burma War Theatre. For his distinguished services in the war, he was awarded two military medals, namely, the Burma Star and the War Medal.

Foreign Travels

Prof Roonwal was a globe-trotter in the true sense and had travelled widely in all the continents except Australia. He was at the University of Cambridge during 1933-35. In 1951-52 he was awarded a Fellowship by the Food and Agricultural Organisation of the United Nations to study termites at the leading centres in the world. He visited serveral countries in Europe like United Kingdom, France, Sweden, Germany, Soviet Union, United States, Ivory Coast (Zaire), the Congo, Egypt, Hawaii Islands, Brazil, Japan, Indonesia, Iran, Nepal, Srilanka, Myanmar and Pakistan.

Association with National and International Organisations

Prof Roonwal was associated with several learned societies, academies, etc. both at the national and the international level. His association with UNESCO lasted for about

8 years in various capacities such as Member, Internationl Advisory Committee on Humid Tropics Research (1957-65), Chairman, UNESCO's Key Zoological Collection Committee (South Asia and South East Asia) (1960-65), President UNESCO's International Symposium on Termites in Humid Tropics (1960), Chairman, UNESCO's International Committee for Termites (1962-64). He was also a Member, Section of Forest Protection, Internationl Union of Forest Research Organisation (IUFRO, Viena) (1954-70).

Dr Roonwal was elected Fellow of the Indian National Science Academy (formerly National Institute of Sciences of India) in the year 1945. He also served INSA as a Member of the Executive Council (1961-63). Soviet Entomologists honoured him by electing him as Honorary Member, All Union Entomological Society of Soviet Academy of Sciences, Leningrad (USSR) in 1969. He was also Fellow of the following Societies and Academies in India : (i) Founder Fellow of the Zoological Society of India and its President from 1957-60, (ii) Fellow, Rajasthan Academy of Sciences and its President from 1951-52, (iii) Hony. Fellow. Indian Academy of Zoology (elected in 1959), (iv) Honorary Fellow, Ceidological Society of India (elected in 1967), (v) Member Advisory Council, Bombay Natural History Society, Bombay (1954-64), (vi) Hony. Member, Entomological Society of India (elected in 1979), (vii) Chairman, Indian National Committee, International Society of Tropical Ecology (1970-73) and (viii) President, Section Zoology and Entomology, Indian Science Congress Association (1945).

Medals and Awards

In 1956, Zoological Society of India awarded to Dr Roonwal, Sir Dorab Tata Gold Medal for his outstanding contributions in Zoologyy during the period 1952-54. Indian National Science Academy honoured him with Har Swarup Memorial Lecture Award in 1984. He was awarded Burma Star and War Medal for his defence service.

Association with Committees of Government of India and Allied Organisations (Arranged Chronologically) :

Dr Roonwal was associated with several Committees of the Government of India and allied organisations, both in his official and personal capacities, thus :

(i) Secretary General, Indian Board for Wildlife, Government of India (1956-62), (ii) Member, Indian Historical Records Commission, Government of India (1958-62), (iii) Member, Board of Trustees, Indian Museum, Calcutta (1956-62), (iv) Treasurer, Indian Museum, Calcutta (1957-58), (v) Chairman, Managing Committee, Indian Museum, Calcutta (1960-61), (vi) Chairman, Entomology and Animal Pests Committee of the Indian Council of Agricultural Research (1960-64), (vii) Chairman, Government of India's Committee on Preservation of Types of Fauna and Flora of India (1960-62), (viii) Chairman, Termite Committee, National Building Research Organisation, Government of India (1960-64), (ix) Chairman, Biological Research Committee, Council of Scientific

and Industrial Research (1965-71), and (x) Chairman, Zoology Panel, Central Hindi Directorate of the Commission for Scientific and Technical Terminology, Ministry of Education Government of India (1970-73).

Listing in World's Reference Works

Prof Roonwal had been listed in some of the World's Reference works as follows :

1. *World's Who's in Science from Antequity to the Present* (Marquins who's who Inc., Chicago (Listed in 1st (1969) to 4th Edition (1977-78).
2. *Directory of International Biography* (London, Cambridge), 7th (1970-71), 11th (1974-75) and 12th (1977-78) Editions.
3. *Men of Achievements* (International Biography Centre, Cambridge), 4th Edition (1976-77).
4. *Reference India* (New Delhi), 2nd Edition (1970).
5. *Famous Indians* (Delhi), 1973-74 Edition.

Scientific Contributions

Prof Roonwal's scientific career spans over a period of about six decades. During his long and uninterrupted scientific pursuits, he made substantial scientific contributions in Zoology and allied sciences. His versatility of mind can be judged from the fact that he had worked on several unrelated groups of animals ranging from Arthropoda to Mammalia. The unmistakable stamp of his thoroughness and erudition is discernible in almost all his publications.

Prof Roonwal began his scientific career in Zoology as a Research Fellow at the Department of Zoology, University of Lucknow under the celebrated Zoologist Late Professor Karam Narain Bhal and worked on the structure, biology and post-embryonic development of the ixora white fly, *Dialeurodes dissimilis* (Hemiptera; Aleyrodidea). The results of these investigations were published in *Nature*, London (1934), *Quart, J. micros. Sci.*, London (1934), *Proc. natnl. Acad. Sci. India,* Allahabad (1936) and *Indian J. Ent.,* New Delhi (1980).

A perusal of the extensive list of the publications would reveal that Prof Roonwal's major thrust in research had been the Class Insecta from the very beginning. Locusts and grasshoppers and later termites became favourite subjects of his investigations. His association with the welknown locust Entomologist, Late Prof M Afzal Hussain, *albeit* brief (1931-1933), kindled in him an abiding interest in locusts and grasshoppers that continued unabated for five decades (1931-1981) even after his direct involvement in the Locust Research Scheme was snapped as early as 1939. Since 1951 he studied another interesting group of insects, the termites and contributed substantially to the knowledge

of taxonomy, morphology and ecology of termites. In this group also he received international acclaim and recognition through his several original contributions.

As mentioned earlier, Dr Roonwal earned instant international fame at a very early age of 28 years through his outstanding original contributions on the embryogenesis of the African Migratory Locust, *Locusta migratoria migratoroides* published in the most prestigious periodical, *Philosophical Transactions of the Royal Society of London* (1936, 1937). In these publications, he propounded a new theory, *Multiphased gastrulation*, (1936) in which he authentically demonstrated that in insects the early post-cleavage rearrangement of cells of two of the three primary germ-layers (mesoderm and endoderm) occurs in several spurts of activity (multiphased). This theory was subsequently extended to cover other arthropods (1938-1939). He further postulated a new law of the bitriangular medial concentrations of cephalic appendages in insects and chilopods (1939). These publications were extensively reviewed by international specialists (H Mellanby in *Quart. J. Microsc, Sci.* 1939, Hermann Weber in *Fortschritte der Zoologie,* 1937, *Nature,* London (1940), *A Course of General Entomology,* Moscow, by BN Schwanwitsch, 1949. An extensive summary of Dr Roonwal's contribution to insect embryology has been included in *Embryology of Insects and Myriapods* by OA Johannsen and FH Butt, 1941, New York and London (pp 74-78, 222-246). In Schwanwitsch's book on General Entomology referred to above, Roonwal's name has been included among the internationally acknowledged insect embryologists like Kowalawski, Mechnikoff, Cholodkowski, Heymons, Philiptschenko, Easthman, Ivanov, etc. This is no mean achievement for a youngman of 28 years!

In the field of locusts and grasshoppers, Prof Roonwal published more than 100 original research papers over a period of five decades (1931-81). In locusts and grasshoppers, the main emphasis had been on their population biology, correlation between population density and intraspecific variability in eye-stripe number, metasternal interspace, body-size biometry, elytron pigmentation, sex ratio, food preference, prediction of locust swarming, etc. in the Desert Locust, *Schistocerca gregaria.* He also postulated a new hypotheses for the prediction of locust swarming (1945, *Bull, ent. Res.*). In 1954, Dr Roonwal postulated a new evolutionary phenomenon namely, sharp increase of intraspecific variations in the minimum population as evidenced by the Desert Locust. These contributions of Prof Roonwal have been reviewed in laudatory terms. Professor KD Roeder while appreciating the importance of the discovery of eye-stripes as a significant character to distinguish *solitary* and *gregaria* phases of *Schistocerca,* commented (*Insect Physiology,* 1953, p. 669) that "the relationships of behavioral and physiological differences such as these (*in the histology of eyes in the phases*) to the selective processes underlying species evolution remain to be established." RA Blackith and FO Albrecht, (*Sci. J. Royal College Sci.,* 1959. vol. 27, p. 26) remarked that " Roonwal's reiterated suggestion that the number of eyestripes should be taken into account when measuring locusts is reinforced".

Termites (Isoptera) : Dr ML Roonwal initiated systematic research on termites first at the Forest Research Institute and Colleges, Dehra Dun and then at Zoological Survey of India, Calcutta and Jodhpur. In these studies, he was ably assisted by Drs PK Sen-Sarma, ML Thakur, OB Chhotani, Ms G Bose PK Maiti etc. Besides his own studies, he had established two strong Schools for termite studies both at FRI & C, Dehra Dun and ZSI, Calcutta.

During his 38 years research on termites (1952-1990), Professor Roonwal made significant contributions to the knowledge on morphology, taxonomy, biology, ecology and control of termites. Besides discovering several new taxa including a new family (Indotermitidae), Prof Roonwal had written two important books on termites viz., *Contributions to the Systematics of Oriental Termites* (with PK Sen-Sarma, 1960) and (ii) *Fauna of India* (Isoptera), vol. I, 1989 (with OB Chhotani). The first book had been reviewed favourably in *Nature*, London, *Science and Culture,* Calcutta, *Naturwissenschaften,* Berlin, and *Beitr. zur Entomol.,* Berlin. One of the outstanding contributions of Prof. Roonwal had been the elucidation of evolutionary and taxonomic significance of wing microsculpturing which was first discovered and illustrated by Roonwal and Sen-Sarma (1960). The value of this study was enhanced by the inclusion of the scanning electron microscopic studies. His Chapter on "Biology of Oriental termites" in *Biology of Termites* (Eds Krishna and Weesner) would remain a standard work on the subject for years to come. Dr Roonwal was an urdent advocate of field zoology. According to him, a lot of important discoveries in biology can be made by careful and meticulous field work. Even as a septuagenarian he undertook different field trips. In the field, his schedules of work and long strides in the field would put to shame a person decades younger.

Forest Entomology : This account will remain incomplete if his contributions to Forest Entomology in India is not included. In a series of publications, Dr Roonwal had been able to elucidate the ecological succession of borers of felled logs and methods of their management to save forest wealth through protection of harvested timber. In addition, he studied the natural establishment and dispersal of an exotic lantana bug *Teleonemia scrupulosa* (Family Tinngidae) imported for the biological control of lantana. Other works include detailed investigations on sal defoliator (*Lymantria mathura*) and wilow defoliator (*Lymantria obfuscata*) which were not reported earlier. His most important discovery is the teredinid borer *Bactronophorus thoracitis,* (Teredinidae; Molusca) as a pest of living trees in mangrove forests of Sundarbans, W Bengal. This is the first record of any member of Teredinidae infesting living trees (*vide* opinion of Dr RD Turner, Cambridge, (Mass), USA and Dr DV Bal, Bombay).

Impact of Professor Roonwal's research finding in Entomology had been so great that his works were referred to extensively in several standard books and works of Imms, Weber, Uvarov, Chapman, Grassé, Wigglesworth, Weidner, Wilson, etc.

Mammals and Birds : During his service at the Zoological Survey of India, Dr Roonwal devoted much time and energy in his studies on systematics, ecology and faunistics of mammals and birds. He discovered and described a few new species. His extensive and intensive investigations on the systematics, ecology and bionomics of mammals studies in connection with tsutsugamushi disease (scrub typhus) in Assam, Burma (now Myanmar) War Theatre were considered notable contributions that advanced the knowledge of the group as well as enlightened about the vector of the disease. Since 1965, Professor Roonwal took up studies on the primate behaviour. Based on extensive field work on hanuman Langur (*Presbytis entelus*), he had shown that the evolution of tail form and carriage follows geographical and clinal variations, a northern style with tail looped forward and a southern style with tail looped backward. His *magnum opus* on primates is the book entitled "*Primates of South Asia. Ecology, Sociobiology and Behavior.* (Harvard University Press, Cambridge (Mass) written in collaboration with SM Mohnot.

PERSONAL QUALITIES

The very name of Professor Mithan Lal Roonwal conjures up the image of a person of rare qualities of head and heart who was straight-forward, did not indulge in deceipt with his colleagues and assistants, a warm-hearted person who had the capacity to view things in the proper perspective, an inveterate patriot who would not hesitate to snub his foreign colleagues in order to uphold the national interest. He vehemently opposed the government of India's decision to transfer Late Dr CFC Beeson's collection of Scolytidae and Platypodidae to the British Museum (Nat. Hist). Though he was literally wedded to his scientific work, he never forgot his duties and responsibilities as a family man–a husband, a father, a brother and an uncle. He was perhaps a loner in the traditional atmosphere of his home in so far as his intellectual pursuits are concerned.

As a scientist, he was not only a great seeker of knowledge but also a great dessiminator of the same. His thirst for knowledge was indeed insatiable and he could never think of resting on his past laurels even at an advanced age and utter visual handicap (he lost the vision of an eye due to post-operative complications). In his personal life he was highly organised, methodical, farsighted and stickler of a daily regime. These helped him to preserve important papers, research notes, scientific correspondences, paper cuttings, extracts of reviews of his research publications, personal dairies and other valuable documents collated and collected from 1930-90, his frequent transfers notwithstanding. But for these, he would not have been able to write his autobiography which, when published, will be a valuable document on the history of the growth of zoological research in the world over a period of more than half a century, on eminent men of sciences, land and the people, etc. whom he came in contact with. Though an internationally acknowledged scholar in his twenties, his fame did not go into his head and he remained a humble person. When this author, during his work under him on

termites, foolishly asked him in 1953 as to who would provide the requisite guidance, spat come the reply "I know a little and we will learn together". This incident is cited to illustrate the humility of the man, notwithstanding his incisive and vast knowledge. Though a serious and reserved person creating the apparent impression of unapproachability, he was quite indulgent to the younger scientists and scholars for whom doors of his exalted office and his humble home remained open at any hour of the day, even the night. He also had a knack of spotting talents and moulding them into devoted scientists, and educationists. His encyclopaedic knowledge of Zoology was helpful to several young scholars working in so diverse animals from tiny insects to large mammals and disciplines ranging from ecology, biology, behaviour, conservation, management of national parks, sanctuaries, embryology, evolution, genetics etc. His was probably a restless mind, always searching new pastures of knowledge, as is exemplified by his taking up research on primate behaviour even at an advanced age of sixty-two plus.

He was catholic in the selection of his reading material and would voraciously read any book, be it sociology, history, political science, mythology, botany, geography etc. This indeed broadened his vision and enabled him to take a holistic view in all matters.

The material needs of his life were few. He was indeed an epitome of the cardinal principle of simple living and high thinking. He was uncompromising in matters of principles, justice and fairness and also possessed a very high sense of dignity. These often landed him in confrontation with his superiors and to lesser extent with his subordinates. This had created among men around him an erroneous impression of a confrontist. He was undoubtedly nonconformist but definitely not a confrontist.

I may add with authority that behind his stern exterior, Dr Roonwal had tenderness and innocence of a child–humane, endearing and funloving.

He inherited from his forefathers not only a good and hardy physique but also highly disciplined nature, a strong will-power, a kind of stubborn determination, firmness of character, sense of justice and team-spirit, the last one was greatly strengthened by his brief sojourn with the defence services.

Dr Roonwal was an administrator par excellence, a quality rarely observed among scholarly persons. He was firm and quick in taking important decisions. Procrastination and prevarication were alien to his nature. However, his approach to matters of administration was a judicious blending of firmness with flexibility. The blue-print that he prepared for the expansion and growth of the Zoological Survey of India will serve that organisation for a long time to come.

In his food habit he was catholic in taste, but a strict teetotaller. Though vegetarian with simple food, he often enjoyed non-vegetarian food in the company of his junior colleagues, students and guests from overseas while on tour within the country or abroad. His was a completely integrated personality and this sums up his pesonal qualities.

One of the remarkable qualities of Professor Roonwal is that he used to exchange considerable amount of correspondences with the scientists all over the world. He used to draft these letters mostly by himself. He was especially indulgent to young scientists and endeavoured to help them in more than one ways. To his pupils and associates, Professor Roonwal was a father figure to whom all looked for guidance and sagacious advice even at the hours of their personal travails and miseries. Professor Roonwal never failed to answer them very promptly in his bold handwriting which did not shake or distort a bit even at an advanced age of 82.

Professor Roonwal breathed his last on the 22nd July 1990 at his residence in Jodhpur due to massive heart attack after he had eaten his supper. In his passing away , the Indian Zoologists lost their doyen and the world Zoology has become poorer. Posterity remembers with affection and gratefulness only those whose contributions to knowledge was really great and abiding. They alone count in the history who not only moulded the minds of their contemporaries but also fashioned the minds of younger generations by their acts and deeds. Prof Roonwal was one of them and will be remembered for ever.

In conclusion, one would not hesitate a bit to record that Professor Roonwal was undoutedly a scientist, educationist and administrator of rare excellence. I end by quoting Oliver Goldsmith :

"And still they gazed and still the wonder grew,
That one small head could carry all he knew".

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JOHN BICKNELL AUDEN

(1903 – 1991)

Elected Fellow 1938

In JOHN BICKNELL AUDEN'S time authoring a Memoir of the Geological Survey of India used to be considered the high water mark of an officer's entire career, and one could hope to bring one out after about 15 or 20 years of dedicated work, covering an extensive area, often geologically virgin, and embodying the results of a number of papers, brief but original, in the records. Auden, however, brought one out on the Vindhyan formation in parts of Mirzapur district (UP), stressing upon its sedimentological aspects, in the seventh year of his service and only after a few months of fieldwork spread over parts of two field seasons. This could have been a veritable record of achievement, and this was the metal John Bicknell Auden was made up of. The present author was later called upon to extend Auden's map eastward to UP Bihar boundary. He had by then, put in about 20 years of field work, and yet to his chagrin he found that the question of introducing any changes in the lithological subdivisions recognized by Auden simply did not arise. However, in the course of a conversation during his visit to deliver the Dinshaw Nowsherwan Wadia Lecture at the Indian National Science Academy session at Benares in 1980, Auden commented that if he was to tackle the problem today, he would do it very differently. How? One can only wonder. But coming as it did from Auden himself one could only wish that Auden had had the opportunity to go over the area all over again so that the Indian geological community could learn what Auden had in mind and how he had grown in the status in geological arena. What changes he envisaged would certainly have been exceedingly interesting to learn.

Auden was the last European to join the Geological Survey of India, and the last to leave it, albeit prematurely, but he left his mark on any thing he touched, howsoever casually he might have come by it. Flying over to Bombay on a fine, clear day, he noticed the dykes associated with the Deccan Trap flows, recognised therein a pattern, and returning to Headquarter, studied the literature and came out with an exceedingly original and interesting paper. That was Auden!

Auden's devotion has undoubtedly been unmatched in the entire history of the Survey. There has, certainly, been no officer in the Department who spent his European furlough on several occasions in traversing the High Himalayas with his own high altitude equipment and at his own cost in travel expenses, field guides and manual transport. He published the results in the *Records of the Geological Survey of India,* and the work attracted world wide attention. He was soon a world celebrity. This was convincingly

demonstrated by the fact that when the well-known Swiss geologists, Heim and Gansser, decided to study the Himalayan geology they desired that they be introduced to the area "by one of its greatest experts, John Auden" (Gansser, 1991). This was agreed to by the Director, Geological Survey of India and accordingly, they accompanied Auden in his field area above the Mussouri Hill station, with a background of over 200 km of glacier covered High Himalayas. During the days John Auden acquainted us with facts of the highly complicated geology of the Krol belt, the subject of one of Auden's best publications, 'The Geology of the Krol belt, 1934'. He already recognised the various lighologies and structures, but he was very cautious in assigning ages based on the scarce and unconvincing fossil evidence (Gansser, *Ibid*). One wonders how much of the universal renowned Heim and Gansser earned subsequently by their publications on the geology of the Himalayas was the consequence of these introductory lessons from Auden.

Auden's most important contributions to the geology of the Himalayas resulted from his extensive field work and mapping during the period 1929-1935. The results were published in two papers (1934 and 1937) in the *Records of the Geological Survey of India*. The problems that Auden focussed on and that remained unsolved then, still remain unresolved, in spite of the immense amount of work put in during the last six decades. In Sikkim and eastern Nepal Auden observed that between the Daling horizon and the Darjeeling Gneisses there was progressive metamorphism upwards. This had earlier been noticed by Louis de Loczy and vividly discussed in 1878. It is still being debated. Loczy's suggestion that there was a recumbent fold in the area not having been found to be convincing (Gansser, *Ibid*). In 1937 Auden joined the Shaksgam expedition for four months under the leadership of Eric Shipton. They were exploring the glaciers and watersheds of the high Karakorum and Aghil Ranges with the 8611 m (28790 ft) Mount Godwin Austen (K_2), the well known second highest mountain peak in the world, having been the only fixed point they could use for locating themselves.

Auden (1976) has provided some interesting details of this expedition. Thus, in order to reduce the baggage the members of the expedition were not allowed to carry with them even essential medicines, with the result that when he and another member of the team, Bill Tillman, contacted malaria and were frequently down with fever, the plans were getting disturbed. Yet, work continued uninterrupted. Auden has said that the expedition, comprising four Englishmen, had cost £840 whereas a modern expedition with elaborate equipment today would have cost at least fifty times this amount.

In 1939 Auden proceeded on an expedition to the Nelong-Gangotri region, apparently on one of his self-sponsored traverses. Alone, with just two porters - one to cook and to look after the camp during the day when he was out and the other to accompany him daily for fieldwork. He could not carry adequate quantities of provisions with him and had to visit the base town, Nelong, frequently to replenish his food supplies. Yet, he is on record that he enjoyed the trip thoroughly. One can only wonder if there is an officer in the Survey today who would like to work in High Himalayas under such conditions.

In northern Sikkim Auden recorded the presence of the rather rare variety of acidic rocks, the white tourmaline granite (leukogranite). Already known since the 1922 Everest expedition, as described by Heron, who had accompanied the expedition, these unusual granites were of absorbing interest to Auden. He noted that they must have been the youngest of the intrusives present in the Himalayas, and like the Chumbi granites, they must be of Tertiary age, for they cut through other Tertiary and earlier intrusives, and occasionaly lit par lit intruded the earlier granites.

Auden was also a member of the team that investigated the 1934 Bihar earthquake, and has co-authored the report.

War brought a sea change in Auden's career engagements. He had to give up his first love, Himalayan geology, and to take up Engineering Geology and Groundwater investigations instead–branches that had shot up suddenly to the front–incidentally proving his versatility. In 1945 he was sent to USA for a five months study tour of the Bureau of Reclamation and Tennessee Valley Authority, and on his return he was made incharge of the Engineering Geology and Groundwater Division of the Geological Survey of India. He was no longer the free lancer of the high Himalayas, although he kept visiting the various dam sites in these mountains. Apart from the large number of dam sites projects that had suddenly come to the attention of the State and Provincial Governments as well as the Central Government for irrigation and power generation, Auden also investigated the various water supply schemes for civil and military establishments, townships and municipalities. Thus, he had to personally investigate all the major dams and all the hydroelectric projects for over ten years in the entire subcontinent, i.e. in both India and the present Pakistan. The multipurpose projects he, thus, investigated included the DVC, Hirakund, Rihand, Bhakra, Beas, Narmada, Tapi, Koyna, Vaitrana, Muttupatty etc. apart from many others that failed to meet the technical requirements. Also, he carried out investigations for suitable dam sites across the Kosi and Kali Gandak in Nepal, as well as those on the Himalayan courses of the Ganga, Yamuna, Sutlej, Beas, Jhelum and Teesta within the Indian territory. These apart, he carried out studies on the groundwater resources in the arid regions of western Rajasthan, Kutch and Quetta. Studying the literature for all these, visiting the field areas, and then writing the reports for each must have needed a super-human effort on the part of Auden. These, the earliest systematic groundwater studies in the country paved the way for extensive studies and widespread drilling operations by the Geological Survey of India, and later led to the establishment of an independent Central Groundwater Board under the Government of India. Yet, Auden remained till the end of his career in the GSI the undisputed monarch in the field. During this period he had often to deal with Mr AN Khosla, an engineer by profession and has gone on record that it was, indeed, "Khosla's devotion and approach which made northern India aware of the importance of the major irrigation projects".

Auden was born in York, one of three sons of the distinguished hygienist, psychologist and archaeologist, Dr GA Auden, who was Professor of Public Health and Medical Officer of the Birmingham University. John spent his childhood in Birmingham and while

one of his brothers went on to become the poet laureate of his time and has devoted one of his poems to John. John, himself went to Cambridge to study Geology. Graduating in 1926, he immediately joined the Geological Survey of India. He was awarded the ScD Degree of the University of Cambridge in 1947.

HONOURS AND MEMBERSHIPS

Just a year after joining the Survey, Auden was instrumental in founding the Himalayan Club, and thus, became its founder member. He was elected a fellow of the Indian National Science Academy in 1938 and President of the Geology and Geography Section of the Indian Science Congress in 1951. He received Gold medal from the Asiatic Society in 1953. After prematurely retiring from the Geological Survey in 1953, he joined the Geological Survey of Sudan for just about $1\frac{1}{2}$ years. He gave it up to join the Burmah Oil Company in London for the next five years. In 1960 he was invited to join the Land and Water Resources Division of the Food and Agricultural Organization of the United Nations and was based in Rome. However, he worked in Afghanistan in 1960-62, and for brief spells in Ceylon, Nepal, Brazzaville, Turkey, Crete, Argentina, Urugray, Panama and South Korea. In 1967 he represented the Royal Geographical Society, London, at the Centenary Celebrations at Rome of the Italian Geographical Society. On his return from FAO he served for two years as the Vice President of the Royal Society of London, and as the Foreign Secretary of the Geological Society of India.

Going back to his days in the Geological Survey of India, Auden, in 1939, learnt to fly and made many reconnaisance flights over the unmapped area of the Bijaigarh Shales-all on his own expenses-to locate the pyrite mineralization zone, this being another case of his devotion to advance geological knowledge in the country. On many of these flights, Shiela, whom he married later, used to accompany him.

In 1940 he worked as Petrologist in the Geological Survey of India, and 1944-45 remained incharge of mica production in great demand during the war in Rajasthan, stationed with his team at Ajmer. Earlier, during 1940-42 he worked as part-time professor of Geology at the Presidency College, Calcutta, a post that used to go then to the petrologist at the GSI headquarter.

Auden was different from most other Europeans in an exceedingly significant respect. Till 1935, like all other Britishers, he used to avoid social contacts with the Indians, except in the field. In 1936 however, he had a chance meeting with the well-known Bengali poet, Sudhindra Nath Dutta, and that broke the barrier once for all. He soon became friendly with Jamini Roy, Bishnu Dutt, Shushoban Sarkar, Tulsi Goswami, Apurva Chandra and Shaheed Suharwardi. During this period he was sharing an apartment with Humphry House, who used to mostly put on Bengali dress. This irked the fertility of imagination of the CID officers and House became a suspect. Very often one could see

a gentleman from the CID sitting outside, watching the movements of the duo, and gently questioning the visitors. Auden, too, was not considered to be above suspicion, and one can guess that he was not a really hard boiled Englishman.

Mrinalini Banerjee, in 1939, introduced her sister, Shiela, then fresh from a two years sojourn in Europe, to Auden. Shiela, grand-daughter of WC Bonnerjee the first president of the Indian National Congress, was a distinguished person in her own rights. Her father was then a well-known lawyer at the Calcutta High Court. Soon, as mentioned earlier, she was accompanying him on his flights from the Calcutta Flying Club at Dum Dum, and dining, on return, at Firpo (Auden, 1976). They married in 1940, and she started moving around with him on geological expeditions, not sparing even the brief groundwater and engineering geology visits. They had two daughters, Rita and Anita, now married in England and settled there. They made a very happy family and during his last days the daughters were constantly by his bed-side.

Earlier, Auden was married to an English woman, who once when he was mapping in the Himalayas, went back to England without informing him, leaving him in heavy debt with very expensive credit purchases from three British owned departmental stores in Calcutta. He had to seek a divorce from her.

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SHYAM SUNDER LAL PRADHAN

(1913 – 1973)

Elected Fellow 1966

SHYAM SUNDER LAL PRADHAN was one of the very distinguished entomologist that this country has produced. He made outstanding contributions in various aspects of Agricultural Entomology. Although, he started his career as insect encologist, he later switched over to insect toxicology and can be rightly called as father of Insect Toxicology in India. With his passing away on February 5, 1973, 96 days before his retirement, after a brief illness, ended an era of Pradhan. He dominated Indian Entomological scene for more than two decades from late 50's till his passing away in 1973. As far as I remember he used only S Pradhan as his name and also signed accordingly.

EARLY LIFE AND EDUCATION

A son, who later became famous as Dr S Pradhan, was born to Shri Gur Prasad on May 13, 1913 in village Dihwa (Tehsil, Nanpara) of Dist. Bahraich in Uttar Pradesh, then known as United Provinces of Agra and Awadh. He was the sixth child of his parents. He had four brothers and three sisters. His father was employed as a village level officer in the Revenue Department of UP Government.

Since there was no school in his village, young Shyam Sunder had to walk daily about three kilometers, each way to a school in an adjoining village. He did not like the school and gave up his studies after 2-3 years. Later he moved to Lucknow with his elder brother, and was admitted to a Government school in Class V. After passing Class VIII from Lucknow, he was sent back to his village. Keen interest that he had developed in the studies made him join the Government High School, Bahraich. He passed the High School Examination of UP Board in 1928 with distinction in Mathematics. To continue his studies, he went to Dayalbagh at Agra and joined the Radhaswami Educational Institute. He passed his Intermediate Examination in Ist Division in 1930 and was awarded a Gold Medal. He joined the Lucknow University and in BSc Examination topped the list of candidates of his class. He passed MSc in 1934 from the same University and joined as Research Scholar under the renowned Zoologist of the time, Prof KN Bahl. For his doctoral dissertation he worked on the functional morphology of insects and was

awarded the DSc degree of Lucknow University, in 1938. His thesis was adjudged as the best among those submitted to the University during that year. In 1948 he obtained the PhD degree from Lucknow University for his work done at the Rothamsted Experimental Station, UK.

Family Life

Dr Pradhan was married to Shanti Mudawal, MA daughter of a well known businessman of Kanpur. Pradhans were a happy couple living in complete harmony. Mrs Pradhan is an enlightened lady. She sometimes accompanied him on his visits abroad. They were blessed with two daughters, Shalini and Rajini. Both his daughters are now happily married.

Professional Career

After his DSc Dr Pradhan worked for sometime in the Imperial (now Indian) Council of Agricultural Research (ICAR) Scheme on sugarcane pests at Gorakhpur. He joined the Imperial (now) Indian Agricultural Research Institue (IARI) as Assistant Entomologist at its Karnal sub-station in 1940. He was sent by the Government of India for training at the Rothamsted Experimental Station, UK in Insect Toxicology so that he can establish a school of Insect Toxicology in India. He was awarded PhD degree in 1948 for his work at Rothamsted. On his return from UK he established the first school of Insect Toxicology in the country in the Division of Entomology, IARI. Dr Pradhan became the first Professor of Entomology in 1958 in the newly created Post-Graduate School of IARI, where he organised the curricula for MSc and PhD degree in Agricultural Entomology. Later he was elevated as Head of the Division of Entomology in 1962, the office which he continued to hold till his last breath. Dr Pradhan guided and supervised the research work of the staff and the students of the Division of Entomology. He supervised 65 students (45 for Diploma of Associate, IARI, 1 for MSc and 19 for PhD) for their degree in discipline of Entomology. Today most of his students are occupying responsible positions at various Universities and Research Institutions in India and abroad. Some of them have continued his pioneering work and have established excellent Insect Toxicology Laboratories in their Organisations.

Contributions to Entomology

Dr Pradhan was a very dynamic person with varied interests. This is amply reflected in his contributions to nearly every aspect of fundamental and applied Entomology.

Functional Morphology : In the field of functional morphology he gave entirely new interpretation to the homology of male genitalia of coccinellid beetles; explained the significance of the reassociation of the Malpighian tubules in coccinellid beetles; and helped to clearly understand the coiling and uncoiling mechanism of proboscis in Lepidoptera. Through extensive studies on the histology of the alimentary canal, he was able to show the presence of a fourth type of epithelium in *Coccinella septumpunctata* which plays an important role in the regeneration of the midgut epithelium.

Insect Ecology : Dr Pradhan was a very keen student of Insect Ecology and made very significant contributions in estimating population levels, assessment of crop losses due to insects, effect of environmental factors on insect life etc. One of his most significant contribution was on the *Temperature-development-relationship.*

A large number of workers have tried to work out equations representing the temperature development relationship. Of these, the following equations of Dr Pradhan is said to represent the most accurate relationship between temperature and development.

For constant temperature the relationship is :

$$Y = Y_0 \, e^{-ax^2} \qquad \ldots\ldots\ldots \qquad (1)$$

wherein Y_o represents the highest value of development index, Y represents development index at required temperature, x represents T- t T represents temperature corresponding to Y_o and e represents a constant.

For Variable temperature the relationship is :

$$Y\,(t_1 - t_2) \; \frac{Y_0 \int_{x_1}^{x_2} e^{-ax^2} dx}{t_1 - \theta_2} \qquad \ldots\ldots\ldots \qquad (2)$$

wherein $Y_{(t_2 - t_2)}$ represents average value of developmental index corresponding to temperature fluctuation between t_1 (max) and t_2 (min) at which the corresponding values of x are x_1 and x_2.

A further advance in this line has been in the evolution of a biometer (a ready recknor) for reading the rate of insect development at any temperature and for estimating the amount of development or number of generations in any given period under any range of temperature fluctuation. Dr Pradhan tested his hypothesis by constructing biometers for *Earias fabia, Trichogramma evanescens minutum* and *Chilotrea infuscatellus.*

Extensive use of mathematical equations in his earlier ecological publications, put Dr Pradhan in a different class of biologist, who was well versed in principles of biology as well as mathematics. Till then, it was presumed that only those students who could not grasp mathematics, opted for Botany or Zoology. Stories were also current at that time that mathematical treatments in his research papers were written with the help of

Mrs Pradhan. The present author once casually asked him about this. When confronted with this question he laughed heartily and replied, "Well, this type of heresy has been perpetuated since his first paper of population dynamics was published. Mrs Pradhan had nothing to do with it". "Why did you not contradict it"? I asked, "Why should I? It gave credit to Mrs Pradhan and who am I to take away credit from my wife, even if it is wrong"? replied Dr Pradhan.Such was the personality of this great man.

Another important contribution in the field of Insect Ecology relates to the *Temperature-toxicity-relaionship.* Dr Pradhan showed that the effect of temperature on the susceptibility of insect to insecticides depends upon the combination of the effect of temperature prevailing before, during and after-treatment. He also demonstrated for the first time that the insects' response to DDT varies with the post-treatment temperature. This work of his, published as three papers in *Bull. Ent. Res.* **40** (1949) has been extensively quoted in many text books on Insect Toxicology. Many authors, however, at times did not even give his reference, despite the fact that they had lifted many paragraphs from his papers.

Through the applicaion of his ecological knowledge to grain storage, Dr Pradhan and his associates developed an improved storage structure (Pusa Bin) - double walled structure of unburnt bricks with a layer of thin polyethylene film in between, for village conditions. While the polyethylene film renders the structure impervious to moisture and gases, the brick walls provide safety to the film against mechanical strains and acts as a bad conductor for heat. The dried grain stored in such structures does not gain moisture and hence remains unacceptable to most pest species. Also with the gradual consumption of the oxygen within the structure, the survival of insect that may be present in the grain so stored, gets further reduced. The structure is cheap to make effective against insect damage as well as economical to maintain.

Insect Toxicology : The contributions of Dr Pradhan in the field of Insect Toxicology were on fundamental aspects like the relationship between the particle size of suspensions and insect mortality, the role of cement and wax layers of insect epicuticle in the penetration of insecticides, the resolution of resistance in insects to insecticides into its two components of internal and external resistance. These have quite far reaching applications and have been quoted in various books.

Chemical control of crop pests : Dr Pradhan always had the interest of farmers at heart. This interest led him to devise effective and economical control measures against crop pests, which are suitable for Indian conditions. In India he was first to record insecticide resistance in *Singhara beetle* through monitoring. His contributions on the suitability of various diluents in preparation of formulations of insecticides are definitive. He was the first to initiate the work on relative toxicity of various insecticides to different pest affecting Indian Agriculture. Under his leadership a series of publications came out giving the control schedules for various crop pests. He was very much aware of the hazards of insecticides and, therefore, he always tried to evaluate the environmental

impact of insecticides. In fact, it was under his leadership that insecticide residue work, using bioassay technique, was initiated in the country.

Neem research which is very fashionable, now was initiated by him in the early 60's. He was first to demonstrate a strong insect repellent action of the suspensions made from neem seed. Neem has also been tried in the field successfully. The 'Neem' research now being conducted all over the world in relation to Plant Protection has the origin in the pioneering work done by Dr Pradhan.

Integrated Pest Control : Dr Pradhan visualised that while the, conventional chemical control methods that had so far been developed and put to use, had been quite useful, the time had now come to bring about far reaching changes in the pest control strategy. The country had achieved green revolution with respect to wheat crop during the sixties but the production levels for other crops remained more or less static. Dr Pradhan was quick to realise that the success with wheat was in a big measure due to the fact that the crop in the field did not attract many serious pests, whereas other major crops were subject to depredations by serious pests and despite comparable inputs did not show comparable output like wheat. He, therefore, putforth the idea of adopting an integrated pest control strategy in the country for controlling pests of various crops and organised an International Seminar on Integrated Pest control in New Delhi from Jan. 20-24, 1969 to highlight the utility of the system and to create awareness about it.

PUBLICATIONS

Dr Pradhan published about 200 research papers in various scientific journals both in India and abroad, communicated scores of papers in the annual meetings of the Indian Science Congress and wrote several popular articles both in Hindi and English, to enlighten the common farmer about complexities of pest problems on various crops and the weaknesses in the life cycle of the pest which could be exploited to control them. He was often heard on the All India Radio giving timely suggestions to ward off the seasonal crop pests. He published a book on *Insect Pests of Crops* and another book on *Agricultural Entomology and Pest Control* which he wrote during his last five years, and has been published by the ICAR. Dr Pradhan also initiated the publication of a monthly Entomologists' Newsletter from the Division of Entomology, with the objective to provide the Indian Entomologists with a forum for quick publication of their salient findings and, through its circulation, to make other fellow Entomologists aware of the latest entomological activities in the country.

During the last few months of his life, Dr Pradhan was working on the premise that 'pest control' research needs to be intensified further for achieving increased crop yields in different crops, and he was busy collecting and projecting information on different crops, on this aspect. His last published paper, - *In Tropics Protection Research is More*

Needed than Production Research projects some of his thoughts on the relative roles of production and protection sciences with reference to crop production in the country. Another paper completed just before his death was *Plant Breeding through the Window of Pest Control.* It was read in a Conference of Plant breeders by his successor, Dr NC Pant. Through this paper, Dr Pradhan highlighted to the Plant Breeders that one of the main reasons for their (breeders) not being able to realise the true potential of the high yielding varieties developed by them was the pest component. According to him the potential can only be achieved under a pesticide umbrella.

Recognition and Honours

Dr Pradhan was widely recognized for his contributions in insect ecology, toxicology and intergrated pest management. In 1956, he was invited by the UNESCO to write a chapter on the *'Ecology of Arid Zone Insects'* in the book on *'Human and Animal Ecology'*. The honorarium received by him for this chapter was held as an endowment for instituting a gold medal, to be awarded each year to the most outstanding student of Entomology passing out from IARI, in the memory of his late father. Again in 1970 Dr Pradhan was invited to Porton, UK to present his *Biotic Theory of Locust Cycles* to a select gathering of Acridologists and those engaged in the locust control. He was a member of the FAO panel of experts on Integrated Pest Control. For a number of years, as the Chairman of the Entomology Committee of the Indian Council of Agricultural Research, he guided the planning and implementation of national policies on entomological research, teaching and extension. About a month before his death, he was actively engaged in finalishing the plans for launching an intensive drive for Integrated Pest Control against pest of paddy.

Association With Scientific Bodies

Dr Pradhan was one of the founder members of the Entomological Society of India and held one or the other office of the Society since its inception. He was the President of the Society for four terms of two years each. It was during his Presidentship that the Society celebrated its Silver Jubilee in 1964 and organised the first International Seminar on Integrated Pest Control in 1969. In recognition of his contributions to Science, he was elected a Fellow of the Indian National Science Academy in 1966.

Contact with Other Countries

Dr Pradhan had travelled extensively to several countries as a visiting scientist and for participation in International meetings and seminars. His critical observations on the Status of Entomology in different countries are recorded in his article *Entomology Round*

the Globe. In the 14th International Congress of Entomology, held at Canberra, Australia, in August 1972, he was invited to chair three important sessions. Immediately after his return from the Congress he was invited to Hawaii to advise on the preparation of Syllabus for the special course on Integrated Pest Control.

Dr Pradhan will always be remembered as Father of Modern Applied Entomology and as the Man who got secured the rightful place for Entomology among the Agricultural Sciences in India.

PERSONAL QUALITIES

Most noteworthy personal qualities of his were intelligence and imagination, which enabled him to quickly grasp the nature and intricacies of a problem. He also possessed a keen sense of assessing the qualities of his co-workers and, therefore, was always able to get the best out of them. Being a hard worker himself, Dr Pradhan expected his colleagues and associates to work hard too. His main weakness was that he was very generous and large-hearted.

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K. S. Thind

KARTAR SINGH THIND

(1917 - 1991)

Elected Fellow 1968

DR KARTAR SINGH THIND was one of the most outstanding Mycologists that this country has produced and his devoted and dedicated work in the area of taxonomy of fungi would always be referred to as the classical contribution to higher learning. He was a brilliant teacher who trained scores of postgraduate students who are an asset to higher education in India and abroad.

EARLY LIFE, PARENTAGE AND CHILDHOOD

Dr KS Thind was born on 30 October 1917 in Village Saidpur, Sultanpur Lodhi, Kapurthala, Punjab where the first Sikh Guru Nanak had lived for ten years in a lower middle class farming family. He had five brothers and one sister of whom two were teachers, one was in the Forest Department and the other two adopted the farming profession. Dr Thind during his childhood in his ancestral village developed a desire to improve agricultural crops.

EDUCATION

Dr KS Thind joined Parmjit High School at Sultanpur Lodhi, about 7 Km from his village and used to walk to his school. He passed Matriculation examination in the first division with a distinction.

Dr KS Thind joined Khalsa College, Amritsar which was a premier education centre in the pre-partition days from where he completed his BSc Hons School in 1939 in the first division. He got first position and was awarded Oman Prize. For MSc degree, Dr KS Thind worked on plant diseases under the renowned Plant Pathologist, Dr H Chaudhri, Professor & Head, Department of Botany, Panjab University, Lahore and secured the topmost position in his class and was awarded the prestigious Alfred Patiala Research Fellowship.

Dr KS Thind was awarded a Government of India overseas scholarship to work for PhD under the noted Plant Pathologist, Dr George W Keitt at Wisconsin University, Madison in the USA where he sharpened his scientific skills and decided to continue his research in Mycology and Plant Pathology.

Positions Held

On his return from the USA, Dr KS Thind was in the following positions, Regional Potato Development Officer, Himachal Pradesh Government, in 1949. Lecturer, Department of Botany, Panjab University (located at Khalsa College, Amritsar), from 1949-1957, Reader, Department of Botany, Panjab University (located at Khalsa College, Amritsar), from 1957-1962, Professor, Department of Botany, Panjab University, Chandigarh, from 1962-1976. Head, Department of Botany, Panjab University, Chandigarh, from 1976-1977, Professor of Mycology, Panjab University, Chandigarh, from 1977-1980 and Principal Investigator of PL 480 and DST Projects from 1980 till his demise in 1991.

Research Interest

Having been ably trained in Panjab University, Lahore (now in Pakistan), and USA, Dr Thind pursued his research on systematics and nutrition of fungi, which was of great relevance and need for the country where agriculture is the major avocation. Moreover, after partition, the Botany Department of Panjab University was temporarily located at Khalsa college, Amritsar, Punjab where Research and Teaching facilities were needed to be developed and young Thind took up this enormous task and raised adequate research laboratories. Dr Thind was enthused by his exposure in USA as well as interaction with Prof EJH Corner, FRS from Cambridge University, UK and started floristic studies of fungi from varied regions of the country which was later on extended to Nepal, Bhutan and Sikkim.

Dr Thind became the doyen of Mycology and Nutrition of Fungi in a career spread over four decades. He carried out extensive exploration of fungi in the Himalayas as well as the other far flung areas. His steadfast efforts so impressed the US Department of Agriculture that it provided him PL 480 funds from 1956 to 1986. He also got the Department of Science & Technology, Goverment of India assistance from DST to continue his research. He, along with his students, continued to make valuable contributions on varied groups of fungi of agricultural importance (Myxomycetes, Pyrenomycetes, Discomycetes, Hymenomycetes and Gasteromycetes). These studies on inaccessible and hitherto uncovered Himalayas, revealed many new records and some entirely new taxa with a specific role on degradation of forest biomass adding to the

fertility of soils. Dr Thind introduced tissue system as basis of identity of taxa of higher fungi in India, leading to new system of taxonomy of these fungi. Thus, he developed one of the largest collections of fungi as National Herbarium which is often cited in such preservatories abroad. He made it a point to deposit a part of each collection in other leading herbaria of the world.

Besides this, his contributions in the area of nutrition of pathogenic fungi deal with macro and micro-nutrients, an application in plant protection to combat the varied crop and fruit plant diseases.

Dr Thind published over 200 research papers in journals of repute in India and abroad. He wrote three comprehensive monographs, several reviews and delivered presidential addresses of learned scientific bodies. His research work has been widely quoted in research papers and text books.

Dr Thind guided several MSc Hons School and over two dozen PhD students who are holding responsible positions in various universities/institutions in India and abroad.

Dr Thind, along with his associates, developed a very strong school of Mycology and Plant Pathology of Panjab University, Chandigarh which possesses one of the largest collections of higher fungi in the world.

AWARDS, HONOURS AND SCIENTIFIC RECOGNITIONS

For his classical original contributions in Mycology and Plant Pathology, Dr Thind had been honoured by several scientific bodies of higher learning of National and International levels including the Fellowship of Indian National Science Academy, New Delhi in 1968. Some of these distinctions were the following :

Membership of Sigma xi, USA, 1948; Fellowship of the National Academy of Sciences, 1958; Fellow, Indian Academy of Sciences, 1960; Member, International Mycological Association, 1972-83; President, Indian Phytopathological Society, 1972; President, Section of Biological Sciences, National Academy of Sciences, 1973; President, Indian Botanical Society, 1973; President, Section of Botany, Indian Science Congress Association, 1975; President, Mycological Association of India, 1979; Chairman, Committee for the Development of Asiatic Mycology, 1977-83; Honorary Fellow, Indian Mycological Society, 1979; Awarded Panchanan Maheshwari Gold Medal, Indian Botanical Society, 1979; National Lecturer, University Grants Commission, 1982; Awarded TS Sadasivan Endowment Lectures of INSA, 1982 and Honorary Fellow, INSOP, 1988.

He participated in and chaired sessions at the National and International symposia and visited various European countries and USA in pursuit of his academic interest.

Marriage and Personal Life

Dr KS Thind was happily married to Sardarni Harjit Kaur, a modestly educated lady who lent him full support in his endeavour as benefactor of humanity through research and development efforts. She handled the household and education of their daughters Govinder and Rupinder, who are happily married. Dr Thind was a humble, kind-hearted person who had immense affection for his students with whom he would freely discuss the scientific knowledge. He took care of his students, helped them in building their careers. He was an epitome of simple living and high thinking. He was fond of walks and enjoyed good health. Dr Thind, true to his rural heritage, continued to have great concern for his brothers in his native village. He tried and succeeded in settling one child of each of his brothers gainfully and continued helping them economically also.

His Last Days

Dr KS Thind was found to be suffering from prostrate cancer in 1986, but it never deterred him from following his chosen path of research and developmental activities. He would attend his laboratories regularly to guide postgraduate students and render valuable advice to the faculty.

Dr Thind passed away on 3 December 1991. He would always be remembered by his colleagues, students and countrymen with respect, gratitude and reverence for his contribution to Science and devotion to duty.

Acknowledgement

Thanks are due to Mrs Harjit Kaur, wife of Dr KS Thind for supplying numerous details of personal life of Prof Thind.

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PhD STUDENTS GUIDED BY DR KS THIND

1962 Gurdip Singh Rawla, "Studies on the nutrition of fungi".
1963 Chuni Lal Mandahar, "Nutritional studies of some pathogenic fungi".
1967 Satnam Singh Saini, "Studies on the trace elements nutrition of some important pathogenic fungi".

1969 Sarjit Singh Rattan, "Studies on the Thelephoraceae of India".
1969 Harnek Singh Garcha, "Studies on the Helotiales of India".
1969 Karnail Singh Waraitch, "Studies on Indian Operculate Discomycetes".
1969 Harmander Singh Khara, "Studies on the Hydnaceae of India".
1971 Kuldip Kaur, "Nutritional studies of some fungi".
1972 Mira Madan, "Studies on the nutrition of some pathogenic fungi".
1976 Sukhwant Singh Dhillon, "Studies on the Myxomycetes of North-Western Himalayas".
1976 Joginder Singh Dargan, "Studies on the Xylariaceae of North-Western Himalayas".
1976 Subash Chander Kaushal, "Studies on the Operculate Discomycetes of North-Western Himalayas".
1976 Mohinder Pal Sharma, "Studies on the Inoperculate Discomycetes of Noirth-West Himalays".
1976 Ranjit Singh Dhanda, "Studies on the Polyporoid fungi of North-Western Himalayas".
1977 Inder Pal Singh Khurana, "Studies on Clavarioid fungi of India".
1977 Inder Pal Singh Thind, "Studies on the Gasteromycetes of North-Western Himalayas".
1982 Rishi Kauushal, "Studies on Operculate Discomycetes of Eastern Himalayas and adjoining hills".
1983 Brij Mohan Sharma, "Studies on the Gasteromycetes of Eastern Himalayas and adjoining hills".
1983 Gurpal Singh Dhingra, "Studies on the Thelephoroid fungi of Eastern Himalayas and adjoining hills".
1983 Ram Murti Sharda, "Studies on the Clavarioid fungi of Eastern Himalayas and adjoining hills".
1984 Raghunandan Sharma, "Studies on the Helotiales of Eastern Himalayas and adjoining hills".
1986 Rajesh Sharma, "Studies on the Myxomycetes of Eastern Himalayas and adjoining hills".
1987 Surinder Singh Virdi, "Studies on the Polyporoid fungi of Eastern Himalayas and adjoining hills".

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PRESIDENTIAL ADDRESSES

1973 The Myxomycetes in India (42nd Annual Session, Biol. Sci. Sect., Allahabad). *Proc. Nat. Acad. Sci.* India (Annual Number), **77**, 47-64.
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1980 Basidiocarp anatomy and its importance on the systematics of Aphyllophorals (7th Annual meeting Myc. Soc. Indan. Jaipur), *Kavaka,* **8**, 1-16

SPECIAL LECTURE

1983 Tissue concepts in fungi, (Prof. TS Sadasivam Endowment lecture, INSA). *Proc. India. Nat. Sci. Acad.,* **49B**, 466-497.

KRISHNASAMY RAMIAH

(1892 - 1988)

Elected Fellow 1942

BIRTH, PARENTAGE AND EARLY YEARS

KRISHNASAMY RAMIAH was born on 15th April 1892 at Kizhakarai, a small coastal town of Ramnad district of the erstwhile Madras Presidency, now coming under Tamilnadu. His father, late Krishnaswamy Iyer was a sea customs Superintendent and worked during his career mostly in the coastal towns of Southern India. Ramiah's mother Kuppamma hailed from Manamadurai, Tamilnadu and belonged to a family traditionally known in the science of 'Aurveda'. Ramiah had four sisters and an elder brother. He had his early education in Madurai, Tamilnadu and won medals and certificates. He was fond of participating in dramas and sports activities of the school. Ramiah was married to Janaki Ammal from Chikkamagalur of Karnataka State.

According to Ramiah's son Mr R Ramachandra (a UN expert in agriculture) now living in Bangalore, Ramiah appears to have been greatly influenced by his sister's husband, Mr. Ramaswamy Sivan, who retired as the Principal of the Agricultural College Coimbatore. Young Ramiah joined the Government Agricultural College, Coimbatore and obtained a diploma in agriculture in 1914.

PROFESSIONAL CAREER

Beginning as research assistant to the economic botanist in the Agricultural College and Research Institute in Coimbatore (1914-1921), Ramiah rose steadily to great heights in his professional career gaining national and international recognition. In Coimbatore he worked for 23 years, first under Parnell and later with his own expertise on rice breeding. He was deputed for two years (1926-28) to the Cambridge University for higher studies where he earned a MSc degree under the famous biometrician Sir Frank L Engledow, FRS. On returning to India, he was appointed as Paddy Specialist to the Madras Presidency in 1930. From 1937 to 1945 his services were lent to the Institute of Plant Industry, Indore where he worked as Cotton Geneticist. In 1946, the Government of India invited Ramiah to negotiate and establish a Central Rice Research Institute. He surveyed all parts of India and chose the state of Orissa as the site for this Institute. Ramiah took over as the founder Director of that Institute at Cuttack in Orissa and

served in this capacity for several years (1946-1951). He was responsible for the organization of separate departments of Cytogenetics, Plant Breeding, Plant Physiology, Agronomy, Pathology, Entomology and Biometry in the Institute. Due to Ramiah's initiatives students were able to carry out research at CRRI Cuttack and obtain MSc and PhD degrees from the Utkal University, Bhubaneswar. Ramiah was admired and loved by the staff and students of the CRRI. He took over as the Vice-Chancellor of Utkal University of Agriculture and Technology at Bhubaneswar, Orissa and served in that capacity from 1965 to 1968. Even to-day, the University cherishes him for his contributions to the development of education and transfer of technology in agriculture in the State of Orissa. Ramiah was awarded the DSc degree of Utkal University in 1955. International recognition resulted in the appointment of Ramiah as a member of the FAO's standing advisory committee for agriculture and later on as a FAO expert. His connection with FAO began in 1946 and lasted until 1957. Even after retirement in 1951, Ramiah continued his activity in an advisory capacity as a representative of national and international bodies and committees until 1974.

A major part of Ramiah's professional career was devoted to rice genetics although he had an opportunity to work on cotton genetics as well for a while at Indore. No wonder that he was affectionately known as 'Rice Ramiah' by his close friends and admirers. Even today his monograph on 'Rice Breeding and Genetics' speaks volumes on his mastery over the chosen field of specialization.

The cultivated rice belongs to the species *Oryza sativa* L. whose original home is South East Asia from where it spread to different parts of the world. Due to constant cultivation over centuries, evolutionary traits have accumulated in this species leading to the formation of different varieties or races. Three distinct races have now been recognized. They are (1) *O. sativa var. indica* grown all over the tropical regions, (2) *O. sativa var. japonica* grown in warm temperate regions (Spain, Italy, Japan, West USA) and (3) *O. sativa* var. *javanica* grown in tropics as well as warm temperate regions (Indonesia, Madagascar and South USA). The first two races are related by distinct morphological and physiological characters while the third is somewhat intermediate showing morphological characteristics akin to *indica* and physiological characteristics akin to *japonica* varieties, *O. sativa* var. *Indica* race is generally suitable for low fertility conditions unlike the *japonica* race which are bred under high fertility conditions. Realizing the fact that soil fertility holds the key to increased production of rice in tropical regions, Ramiah's strategy aimed at combining the characteristics of *indica* and *japoncia* varieties by extensive hybridisation programmes. To achieve this, a catalogue of genetic stocks of rice at the global level was necessary and Ramiah's efforts were also concentrated in this direction.

Under a scheme financed by the Indian Council of Agricultural Research, a survey was undertaken in Jaipur tract of the Orissa State which has an elevation of 300-600 metres above sea level and where rice has been traditionally grown by 'Adibasis' without interference by the introduction of exotic varieties. The races of rice collected from this

rich pool of natural variations have proved valuable for rice geneticists. During the survey, *Oryza perennis*, the immediate progenitor of cultivated rice was collected along with several intermediate types arising out of natural crossing between *O. perennis* and the cultivated rice. Even during Ramiah's tenure in Coimbatore from 1914 to 1921, he had collected 2000 varieties of rice including wild types, different species and some interspecific crosses. One of the important diseases of rice is the 'rice blast' or the 'tikka' disease (Spots on leaf) caused by the fungus *Pyricularia oryzae.* Ramiah's efforts were geared to introduce the resistance factor to some genotypes for this phytopathogen. His efforts led to the development of varieties resistant to rice blast disease. The well known among these varieties are the CO-25 and GEB-24. One of the varieties ADT-10 selected by him for short duration of maturity had been under cultivation in the Tanjore delta for nearly 3-4 decades. The *indica* x *japonica* hybridisation programme had not only expanded our understanding about the evolution of cultivated rice but also yielded many popular rice varieties. In this connection mention may be made of ADT-27 for Tamilnadu and Mahinja and Mahsuri for Malaysia.

Collaborative work with Dr N Parthasarathy FNA expanded Ramiah's scope of interest in rice genetics. Writing the obituary acticle in 1988 for *Current Science* vol 57, 1031-1032, Dr MS Swaminathan FNA writes, "With Dr N Parthasarathy, he initiated work on rice hybridization and induction of mutations with X-rays. His contributions to our understanding of rice were wide ranging, covering both qualitiative and quantitative traits. His work on gene identification and symbolization, construction of linkage maps and classification of rice varieties according to grain quality still remains a classic. Above all, he was one of the earliest to understand the close correlation between plant architecture and response to good soil fertility and water management." When the writer of this memoir, requested Dr Swaminathan recently to sum up the work of this doyen of rice genetics in two or three sentences, he (Dr MS Swaminathan) wrote as follows, "DrRamiah was a Scientists' Scientist. He was the embodiment of dedication to a cause, which in his case, was more and better quality of rice for the world. He harnessed for this purpose every tool science provided. His life and work will remain for ever an affirming flame in the Indian agricultural science horizon".

As mentioned earlier, Ramiah joined the Institute of Plant Industry in 1937 and worked there unitil 1945. During that period he collaborated with Prof Sir Joseph B Hutchinson on the standardisation and description of different varieties of cotton which resulted in a monograph on cotton varieties. Even though Ramiah's versatality could have helped any crop including cotton, it has been said that his first love was for rice.

INTERNATIONAL CONTRIBUTION

Ramiah drew the attention of the FAO and the UN to the need for constituting an International Rice Commission which indeed materialized. In 1951, two working parties, one on rice breeding and the other on problems of rice soil fertility were constituted

and had meetings in successive years in different countries of Asia. An outcome of this venture was the organization of two International training centres on rice breeding by the FAO and Government of India once in 1952 and later in 1955. The objective at that time was to fill the lacunae in trained manpower and facilities required for organized programme in rice breeding. Another outcome of this joint venture between the FAO and the Indian Government was the production of a world catalogue of genetic stocks of materials available in different countries. Many cooperative projects among Asian countries emerged, one of which was the project dear to Ramiah on the extensive hybridization programme between selected *Japonica* and *indica* varieties. The *Japonica* varieteis came from Japan and the *indica* ones came from different countries of South East Asia. The first crossings were done at the Central Rice Research Institute, Cuttack and the first filial generation plants (F_1) were raised in Cuttack. The seed of the F_2 generation was sent to different participating countries so that progenies suitable to local agro-climatic conditions could be chosen by actual field results. The *japonica* varieties are early maturing under tropical conditions coupled with strong straw characteristics which prevent lodging especially in fertile soils.

Ramiah's international initiatives were made at a time when rice production in South Asia and Malaya ranged from 1240-1830 Kg/ha. This low figure was due to the unscientific methods of production. Each country had on record many potential varieties of rice but exchange of materials was unheard of. It goes to the credit of Ramiah that he opened the doors for international exchange of breeding materials by convincing not only his mother country but the FAO as well.

A Builder of Institutions

Ramiah had a mission in life and that was the upgradation of the genetic stock of rice for better yield and pest resistance. Very soon he realized that this task was formidable and needed trained manpower and International cooperation for continuous exchange of breeding materials. To this end, he did not leave any stone unturned. It was due to his foresight that several sub-stations for research on rice was established at Aduthurai, Ambasamudram, Pattambi, Maruteru, Nellore, Mangalore and Berampur in the erstwhile Madras Presidency.

Ramiah convinced the Government of India on the need for a Central Rice Research Institute and he did achieve the goal in setting up this Institute in Cuttack. His overtures in the international area as FAO consultant, his attendence at meetings in Copenhagen (1946), Geneva (1947) and Washigton DC (1948) and representations at various rice commission meetings in Thailand, Burma, Indonesia and other countries were responsible in no mean measure to the creation of the International Rice Research Institute in Manila, Philippines. In all these endeavours he laid solid foundations for the emergence of talented rice scientists in India who have occupied highest positions in these insitutions. He was elected as the president of the Indian Society of Genetics and Plant Breeding in 1944

and the society awarded him a plaque in recognition of his outstanding contributions to plant genetics.

HONOURS AND AWARDS

In 1968, Ramiah was nominated to the Rajya Sabha, serving as a member of Parliament until 1974. He served as a member of Parliamentary Committee that reviewed the working of CSIR laboratories. He also served as the Chairman of a parliamentary committee on problems of agricultural labour.

Ramiah got the prestigious International Rice year Medal in 1961 and the Sunderlal Hora Medal of the Indian National Science Academy in 1969. He was elected fellow of the Indian National Science Academy in 1942 and was the Foundation Fellow of the Indian Academy of Sciences. He was honoured with the titles "Padma Shri" in 1955 and "Padma Bhushan" in 1970.

LAST DAYS

Ramiah was alert and active and maintained full control of his senses during the later years of his retirement in Bangalore. His wife Janaki Ammal passed away in 1985. Some other bereavement in the family later put additional strain on his health. All these events caused deterioration in his health and he was bedridden during the last six weeks of his life. The end came on 2nd August 1988 when he quietly passed away leaving behind five sons, two daughters and a host of scientists and admirers to mourn his death. All his sons and daughters are living and well settled in life.

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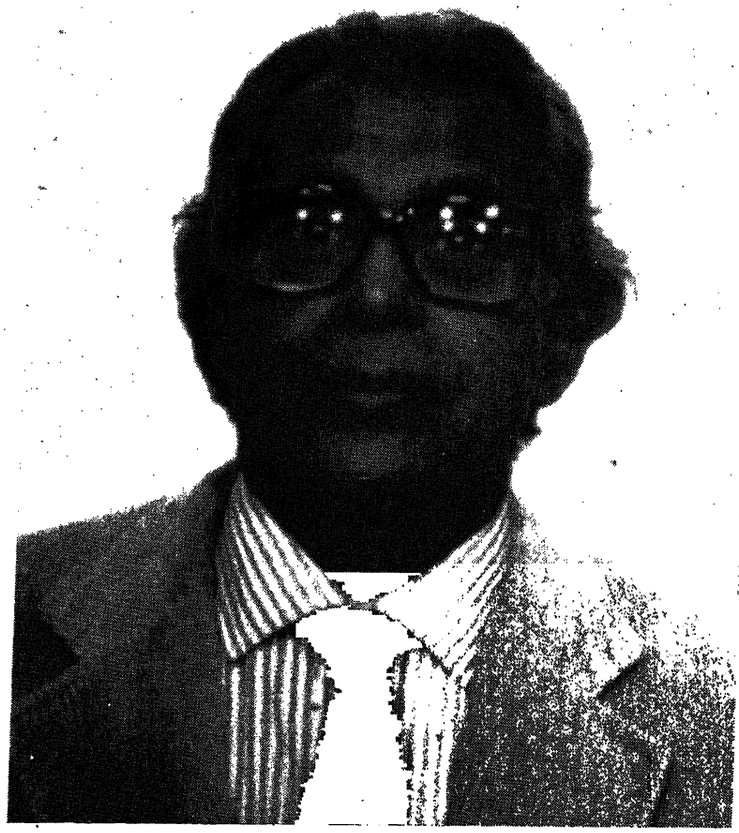

K. S Singwi

KUNDAN SINGH SINGWI

(1919 - 1991)

(Elected Fellow 1964)

KUNDAN SINGH SINGWI was born in Udaipur (Mewar) on March 13, 1919. He was the eldest of four brothers and two sisters. His father Shri Khubi Lal Singwi was Head Clerk in the Revenue Department of Mewar State. His mother Smt. Jatan Kunwar Bai was a highly religious and affectionate lady and Kundan Singh was greatly influenced by her. He was greatly attached to his parents and even when living abroad he visited Udaipur almost every year to be with them. Shri Khubi Lal passed away in 1963 and his mother Mrs. Jatan Kunwar Bai in 1969. After this his visits to India became much less frequent.

CHILDHOOD AND EDUCATION

Singwi spent his early childhood with his maternal grandfather, Shri Meghraj Khimesra. He passed his intermediate examination from Maharana Bhopal College. For his higher education he joined Allahabad University, which in those days was one of the best institutions of the country, with people like Prof MN Saha, Prof AC Banerjee, Prof BN Prasad on its staff. He took his BSc degree in 1938 and MSc degree in 1940. For standing first in MSc in Physics, Singwi was awarded Ward Vidyant Gold Medal and also Empress Victoria Silver Jubilee Medal for standing second in the Science Faculty. In 1949 he received the DSc degree from the same University for his thesis on "Quantum Statistics and its applications".

Soon after his MSc, in 1942 Singwi was appointed Lecturer in the Physics Department of Allahabad University. In 1947 he moved to the University of Delhi as a Lecturer and Research Fellow of the National Institute of Science (now known as Indian National Science Academy). He served here till 1950.

In 1950 he was awarded a British Council Fellowship and he decided to work at the Univeristy of Birmingham, England, with Prof RE Peierls. For a brief period in 1952-53 he was a Research Associate at the University of Illinois at Champaign-Urbana, USA, and in 1953 he joined Tata Institute of Fundamental Research (TIFR), Bombay, as a Reader. In 1954 he was appointed Head of the Theoretical Physics Division of

Atomic Energy Establishment at Trombay (now called Bhabha Atomic Research Centre), a post he held till 1958. During 1953-54 he worked at the Nuclear Research Centre at Saclay, France, under joint Indo-French Collaborative programme.

Dr Singwi joined Argonne National Laboratory (ANL), Illinois, USA, in 1959 as a Resident Research Associate. On his way to USA he spent some time as a Visiting Scientist at the Institute of Theoretical Physics at Uppsala, Sweden. In 1961 he returned to Allahabad University as Professor and Head of the Physics Department. However, he did not stay there for long and the year after he went back to ANL as a Senior Physicist. He worked there till 1968, when he joined Northwestern University, Evanston, USA, as Professor of Physics. He had worked here earlier as a Visiting Professor during 1964. From 1979 to 1982 he was the Chairman of the Department. On retirement in 1989 at the age of 70 he was honoured by being appointed to the Feyerweather Professor Chair of Physics.

Singwi was married to Teeja Bai (neé Khabya) in 1934. They had two daughters, Tara Kumari and Kusum Lata. Unfortunately, his wife died early, in 1950. Tara is married to Prof Kirti Oberoi and settled in Kingston, Ontario, Canada. Kusum, who is a Health Inspector for Detroit Suburbs, is married to Sudar M. Rashid, a metallurgist working for General Motors in Detroit, Michigan, USA.

While in Birmingham, Singwi met Miss Helga Greve in January 1951. She was born at Westerland on Sylt, Germany, and went to England for studying English language and nursing, being greatly influenced by the work of Dr Albert Schweizer in Africa. They were married in Pune (Maharashtra) in April 1953. They have two daughters, Veena and Sunita. Veena has a Master's degree in Social Work and is married to Mr Carlton Ferrono, a psychologist settled in Evanston. Sunita, having a Master's degree in Art History, has a photo studio in Manhatten, New York, and her husband Mr Mark Silverman is a lawyer.

Research Work

Singwi started his research work in the field of Quantum Statistics and applied it for studies of equilibrium abundance of isotopes, white dwarf stars, diamagnetism of relativistic free electron gas and viscosity and thermal conductivity of He^3–He^4 mixtures. In 1947, with BP Agarwal he published a letter in *Nature* proposing a statistical model for multiple particle production in nucleon-nucleon collisions. They postulated that both mesons as well as electrons could be produced in such collisions and calculated their concentrations, and they were able to explain many of the observed results. It is interesting to recall here a conversation between Singwi and Prof RE Marshak, where one of the authors (LSK) happened to be present. Singwi felt aggrieved that though he and Agarwal had published the statistical theory of multiple particle production three years prior to

Fermi's work, it came to be called Fermi's theory. Prof Marshak was of the view that it is not enough to give new ideas and then forget about them. Credit normally goes to the one who gives an idea, realizes its importance and works out its consequences.

While in Bombay and as the Head of the Theoretical Physics Department of AEET, Singwi developed a strong group in reactor physics and neutron physics. They investigated in detail the scattering of thermal neutrons from solids, using the method of second quantization. They studied neutron scattering from graphite, having basically a two dimensional structure, and they explained many observed results for the first time. Thermalization and diffusion of neutrons in moderators like Be, BeO, and graphite were studied in detail and many interesting and new results were obtained. This initiated considerable experimental studies at many laboratories.

Singwi and his coworkers presented papers at the first two conferences on "Peaceful Uses of Atomic Energy", held in Geneva in 1954 aned 1956 (For the first conference Prof HJ Bhabha was the General President). These papers were very well received.

Three persons - LS Kothari, RC Bhandari and PG Khubchandani - worked with Singwi for their PhD, while he was in Bombay. Others who worked with him during that period include Prof BM Udgamkar, Prof SS Jha and Mr BP Rastogi.

In 1959, Singwi joined Argonne National Laboratory. Dr Aneesur Rahman, who was earlier working with him at AEET, joined him a year later. Shortly before that Dr Alf Sjolander from Uppsala, Sweden, had come to ANL, and these three scientists formed a theory group, headed by Singwi. Inelastic neutron scattering was a new experimental tool at this time, introduced in the later part of 1950 and in the beginning mostly used for studying phonon excitations in crystals but later on also for studying atomic motions in liquids. The above theory group was primarily trying to understand the relation between measurable neutron scattering spectra and the microscopic atomic motions in liquids. They also extended their studies to the Mössbauer effect in solids and liquids, discovered by Mössbauer in 1958.

The problem of calculating the ground state energy and the elementary excitations of an interacting electron system was of great interest to many-body theorists in late fifties. Bohm and Pines and Gell-man and Brueckner had developed the Random Phase Approximation (RPA) to deal with this problem. However, it did not work in a satisfactory way for metallic densities and lots of efforts were made in vain to improve the theory. Singwi, together with MP Tosi and A Sjölander, developed the concept of a "static local field" in order to take into account the Pauli and Coulomb hole surrounding each electron. Robert Land helped them with the computer program for solving their non-linear equation for the dielectric screening. The detailed results were published in the *Physical Review* in 1968 and it came to be known as the STLS theory. It became a citation classic according to current contents. A general review of this topic was later written by Singwi and Tosi.

The STLS theory was extensively applied to various problems and the original STLS scheme was further generalized and refined. Among other things, Singwi and Dr Priya

Vashishta generalized it to a system of electrons and holes in semiconductors. Shining strong laser light on some semiconductors one could create liquid droplets in such a two-component system. Contrary to predictions of some conventional theories (*e.g.* RPA, Hubbard approximation etc.) the STLS theory predicted the existence of a condensed electron-hole liquid phase in highly strained Ge and Si. This prediction was later confirmed by experiments.

Kirczenow and Singwi also considered a three component system in Ge, consisting of electrons in a higher valley of the band structure (hot electrons), electrons in a lower valley (cold electrons), and holes. They predicted that under suitable stress conditions the system would separate into two phases, one containing cold electrons and holes and the other hot and cold electrons and holes with different densities. They would form liquids drops with one of the phases constituting the core of the drop with the other phase forming a shell around the first one. Such a phase separation was indeed found in later experiments. A major review article on this whole topic was written by Singwi and Vashishta.

Professor FC Auluck and LS Kothari were sanctioned a major research project in 1972, under PL 480 programme of USA to work on "interaction of thermal neutrons with matter". Professor Singwi was the coordinator in USA. There was continuous and very useful correspondence between the two sides, which helped in producing many research papers in the field. The project came to a close in early 1982.

GENERAL

When Singwi had just joined ANL an old friend, Harry Kipkin, visited him and described enthusiastically a new phenomenon called the Mössbauer effect. Singwi listened for a while but then stopped the conversation by commenting that this was all familiar and corresponded to Bragg scattering of X-ray and neutrons from crystals. The intensity of the Mössbauer line should be given by the well-known Debye-Waller factor. However, noticing the large number of letters and papers appearing in most recent scientific journals he realized the reason for the excitement. Together with Sjölander he formulated the theory of the Mössbauer effect in terms of the Van Hove correlation function, familar from the theory of neutron scattering. This paper has been widely quoted, particularly when diffusive motions of the nuclei are of importance. This story clearly illustrates that Singwi was quick to jump into a new field as soon as he thought he had grasped the basic physics.

Singwi travelled widely and attended many conferences and seminars. He was often invited to lecture at winter/summer schools and he was a frequent visitor to TIFR, Bombay, Chalmers University of Technologyy in Gothenburg, Sweden, and the International Centre for Theoretical Physics (ICTP) at Trieste, Italy. In 1958 he was appointed a member of

the Solid State Science Advisory Committee of ICTP. Singwi's usefulness lay in his interaction with numerous visitors to the Centre for the Summer Research Workshop in Condensed Matter Physics. His human character and scientific ability allowed him to assist, encourage and orient a great number of these visitors, particularly from the Third World.

In connection with Singwi's 70th birthday in 1989, the Centre organized an international symposium in his honour. Besides a large number of his former PhD students and coworker, Prof R Peierls, Prof R Mössbauer, Prof N March, Prof. W Kohn and many other well-known physicists participated.

Singwi enjoyed tennis and swimming. He found relaxation in listening to classical Indian and Western music. Mrs. Singwi and he were regular visitors to concerts in Chicago.

Everybody who came in contact with Singwi and his family noticed their great hospitality and kindness. He was very considerate to his friends and especially to young visitors from abroad. He and his family had a large number of close friends.

HONOURS

Singwi was elected Fellow of the Indian National Science Academy in 1964, and a Fellow of the American Physical Society in 1975. On June 26, 1978, the Ambassador of India in USA honoured Singwi, along with twelve other Americans of Indian origin, for his outstanding contributions to Solid State Physics. He was presented a plaque with the inscription "Exemplar of Excellence and Explorer of Brahma-With Esteem and Affection from the people of India who rejoice in his outstanding achievements". India League of America also honoured him on October 11, 1980, for his contribution to Theoretical Solid State Physics in USA and India.

A plaque with the inscription "The Association of Indians in America honours Kundan S. Singwi for his unique contribution to arts and letters and greater understanding between the Peoples of India and America" was presented to him on May 16, 1981.

On March 31, 1991, Mewar Manch honoured Singwi by confiring on him the award of "Mewar Ratna".

Singwi was on the Editorial Board of Physics Letters for a number of years.

DEATH

Singwi was not keeping too well for the last few years of his life. His troubles began in early 1986. As he records in a letter written on January 7, 1987, "1986 was not a good year for me healthwise. In Febuary 86, I had an attack of bleeding ulcer and was in hospital for a week. Last October I had two minor heart attacks and had to be admitted

to the hospital twice. I underwent a number of tests and I am still on medication. Beginning of this year I have resumed my normal work but I have to be very careful".

Singwi continued to take long walks every morning on the advice of his doctor. He was feeling better and message of his death on October 18, 1991, came as a great shock to all his friends and relatives. He collapsed in the dentist's chair and though he was immediately rushed to a nearby hospital, they could not save his life.

Singwi was a person with great honesty and with a strong feeling of what is right and wrong. He is admired by all who came in contact with him for his enthusiasm for physics. He was a great educator and a perfect gentleman.

ACKNOWLEDGEMENT

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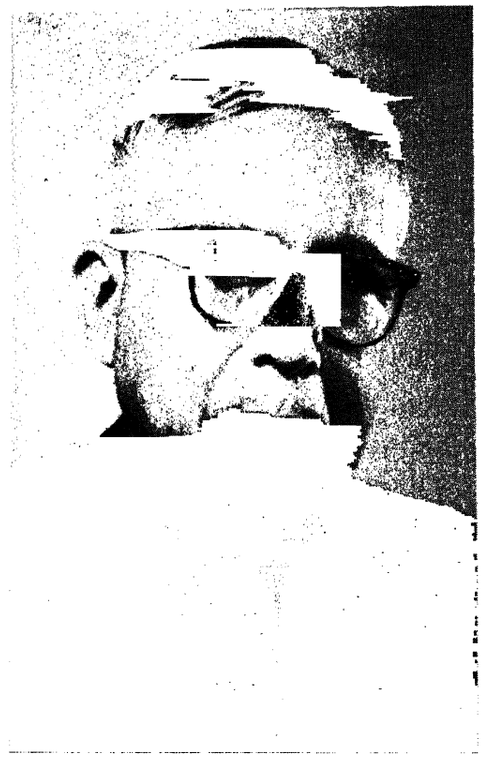

H. Rakshit

HRISHIKESH RAKSHIT

(1906 – 1991)

Elected Fellow 1943

Among the Indian Scientists who carried out significant work on Propagation of Radio Waves (previously called Wireless Waves) and Electronics in their initial stages of development, the names of Professors SK Mitra, FRS and H Rakshit come in the forefront. Their work started as early as the beginning of 1920's. Even to-day investigation in these fields have been actively followed by their students, for example, by Dr AP Mitra, FRS and others.

HRISHIKESH RAKSHIT was born on 8th February, 1906 at Serampore, West Bengal. His father was an accountant in a British mercantile firm at Calcutta. After a meritorious academic carrer and obtaining DSc degree from Calcutta University, he became a Sound Engineer (1933-35) in Radha Film Co, Calcutta. The Sound recording of the famous Bengalee film 'Manmoyee Girls' School' was carried out by him. During the period 1935-44 he was the Assistant Lecturer in the Physics Department, Calcutta University. He obtained Sir Rashbehary Ghose Travelling Fellowship (1938-39), Calcutta University, for studying technical developments in radio and allied fields in UK. He then moved to the Applied Physics Department, Calcutta University, as a Lecturer (1944-48), For the period 1948-49 he was appointed Assistant Director (Electronics), National Physical Laboratory, New Delhi, and then Assistant Professor and Head, Department of Physics and Electronic Communication (1949-55), Bengal Engineering College, Sibpur. Finally, he was appointed as the Senior Professor and Head of the Department of Electronics and Electrical Communication Engineering (1955-66), IIT Kharagpur. He became UNESCO Fellow (1960-61) for studying latest development in Electronics and allied fields in UK, Sweden, Holland and France. During 1966-67 he became UNESCO Expert in Electronics, University of Damascus, Syria.

Prof Rakshit was members and Fellows of many Indian and foreign scientific bodies e.g. Fellow of Institute of Physics, London; Fellow of National Academy of Science, India, and Distinguished Fellow, Institute of Telecommunication Engineers, India.

Mild tempered, soft spoken and widely respected Prof Rakshit, never aspired for betterment of his position unless it was offered to him. He was very much interested in research, higher studies and teaching. This became clear from the fact that when Calcutta University offered him only the post of Assistant Lecturer in Physics Department,

he accepted it and resigned from his position of Sound Engineer in Radha Film Co. Calcutta where he used to get much higher salary.

Prof Rakshit settled in Chandannagar, which was a French possession during British rule in India. He loved to stay there and spent his last days quietly till his death in 1991.

Prof Rakshit's research work can be divided under three heads, Radio Wave Propagation which he carried out jointly with Prof SK Mitra, distributions of O_2 and O in the Upper Atmosphere and electronic circuitry.

(1) Radio Wave Propagation

The work extended over various aspects of Radio Wave Propagation as given below :

Initially Profs Mitra and Rakshit's work concerned, 'Survey of Field Strength of the Broadcasting Transmitter Around Calcutta', and was carried out by measuring resonance voltages across a portable loop aerial. The observations showed that the attenuation of the waves over land is much larger than that over water and that local shadows due to elevated steel structures are wiped out at large distances by the radiations from other portions of the wavefront.

The second phase of the work dealt with 'Propagation of Radio Waves Through the Ionized Heaviside-Kennely Layer (E-layer). Natural fading and the effective height of the layer were measured by the Appleton and Barnett's angle of incidence method. Observations were made with signals from the Calcutta broadcasting transmitter (X=370.4 m). The downcoming waves from the E-layer was received at a distance of 121 km. One vertical and one large loop antenna were used. The lowest height of the E- layer was observed near about sunset. It increases gradually with the progress of night till the end of observation *i.e.* at 11 p.m. The intensity and nature of fading varies from night to night.

Afterwards the 'F-layer at Different Hours of the Day and Night' was studied by the group retardation method. The transmitting antenna was of inverted L-type and a horizontal dipole. The receiving antenna was of the outdoor inverted L-type with a relatively long horizontal portion. It was a single turn square loop. The transmitter was located in the laboratory. The receiver was placed at the beginning at a distance of 3.5 km. Also, the receiving equipment was carried in a small bus and recorded at various distances and in different directions.

'Diurnal and Seasonal Variations' were also recorded. The multiplicity of echoes was observed mostly during sunset. A constant interval between consecutive echoes indicated that these were due to multiple reflections between the earth's ionized layers.

Prof Rakshit participated in the 'Polar Year (1932-33) Observations of Upper Atmospheric Ionization'. These observations were carried out for λ = 75 m. The receiving loop antenna was permanently located at a distance of 7 km from the transmitter. The

diurnal and seasonal variations of height showed that the echoes are abnormally strong during sunrise and sunset periods.

Towards the end of the Polar Year, the 'Ionization of the Upper Atmosphere' was measured. It showed that the diurnal variation of ion content agreed fairly well with the Chapman's theory. There were however, days when the agreement was poor.

'The Depth of Penetration of Radio Waves Inside the Conduction Layer' was also measured by Profs Mitra and Rakshit for obtaining the gradient of ionic density. This was done from observations of magnetic splitting of the waves. Ordinarily, transmitted pulse was split up by the earth's magnetic field into two components. The time interval between the arrivals of two waves depended on the gradient of ionization-the greater the gradient the shorter was the interval. From a knowledge of this interval and the average group velocity of waves in the region, the depth of penetration was calculated.

Splitting was found to be more frequent and the time interval was much longer for F-layer reflection than for E-layer. With the progress of night, the average F-layer height increased and so also the time interval leading to reduced ionization gradient.

Profs Mitra and Rakshit showed that 'Meteoric Showers Caused Increased Ionization' and showed that the results were based on available knowledge of $T = 100^0$ K at 80 km with linear increase of 4^0 K/km and pressure = 10^{-1} mm at 100 km with the same relative atmospheric composition of N_2 and O_2 as at ground.

(2) *Distributions of O_2 and O in the Upper Atmosphere*

Prof Rakshit showed that due to dissociation of O_2 molecules by the absorption of solar ultraviolet radiations, the density of O_2 decreases very rapidly with height above 100 km. On the other hand, the density of O, which is almost zero at 80 km, increases rapidly with height, attains a maximum at about 105 km and then decreases gradually. The transition layer in which O_2 decreases rapidly plays an important role in the production of E-layer.

(3) *Electronic Circuitry*

Prof Rakshit also carried out significant work on Electronics Circuitry. He developed a noiseless recording system, a 3-phase RC oscillator for producing wideband FM and delayed coincidence method for measuring ionospheric heights. He also fabricated electronic torque-meter with remote control.

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S. Ananta Krishnan

SEKHARIPURAM VENKATESWARAN ANANTAKRISHNAN

(1908 – 1989)

Elected Fellow 1966

SEKHARIPURAM VENKATESWARAN ANANTAKRISHNAN was born on October 4, 1908 at Ponnani in the Malabar District of the former Madras Presidency. His father, Sri S Venkateswara Iyer was at that time employed in the office of the Inspector-General of Police. Anantakrishnan had his schooling partly in Madras City (1913-17) and partly in Cuddalore (1917-24). In 1924 he joined the Government Victoria College, Palghat for the Intermediate Course and moved over to the Presidency College, Madras in 1926 for the Bachelor's course in Chemistry. After receiving the BA degree in 1928, he qualified for the BA (Hons) degree in 1930 and the Master's degree in 1932. His school and collegiate career was marked by uniform brilliance.

Anantakrishnan was sent to England in 1931 ostensibly to sit for the ICS examination. There in London he attended a lecture by CK Ingold which impelled him to pursue a career in chemistry rather than civil service. He joined the University College, London for his doctoral research under Prof Ingold, the doyen among the physical organic chemists of the world. The training he received under Prof Ingold was to leave an indelible impression on Anantakrishnan's own subsequent researches in India. His work on the additive reactivity of ethylene derivatives earned for him the PhD degree of the University of London in 1934.

Returning to India the same year, Anantakrishnan joined the Travancore Sugars Ltd., as a Chemist. A year later he accepted a position as a Chemical Assistant at the Government Test House, Alipore, Calcutta. Anantakrishnan used to fondly recall this period and was proud of the fact that one of his colleagues there at that time was Dr Atma Ram who later bacame the Director-General of the CSIR of the Government of India.

However Anantakrishnan's keen interest in academic activities took him to the Annamalai University in 1937 where he accepted the chair of chemistry. While his research work at the University was mainly in the field of reaction kinetics, his interests extended to natural products as evidenced by his publication in 1942 on the constituents of the seeds of *Croton Sparsiflorus* (Morung). The year 1942 marks an important point in his life as he moved to the Madras Christian College, Tambaram to begin an illustrious career as a teacher-researcher. His association with this famous institution spanned more

than two and a half decades during which period the Department of Chemistry grew in strength to become one of eminence. It must be remembered that the department was essentially an undergraduate teaching wing till 1958. Yet it was here that Anantakrishnan did his pioneering work in several areas of chemistry undaunted by the lack of physical facilities or by financial constraints. The circumstances were such that anyone else with lesser zeal and dedication to the cause of chemical education and research would have gone into academic oblivion. His intellectual stature and inspiring leadership were such that highly significant research findings came out of his laboratories despite meagre infrastructure. Even as an undergraduate department, it was recognised for research leading to the MSc and PhD degrees by the University of Madras. It was upgraded to post-graduate status in 1958 when the new MSc course was introduced by the University, but much earlier than that Anantakrishnan had established the department as the focal point of research in reaction kinetics in India and put it firmly on the scientific map of the country. Almost all foreign chemists of repute visiting South India would stop at Madras Christian College to see for themselves how research work of such calibre could emanate from what was essentially an undergraduate teaching department.

Physical organic chemistry, particularly the study of organic reaction mechanisms by kinetic methods, was largely unknown in India till 1942. Anantakrishnan initiated research work in such diverse fields as the addition of bromine to alkenes, the Menshutkin reactions, the acid-and base-catalysed hydrolysis of esters including diesters, and the oxidation of a wide variety of substrates such as alcohols, aldehydes, arylalkanes, etc. It could be stated without fear of contradiction that there was no other school of physical organic chemistry in India in the fifties and the early sixties which was engaged in the investigation of such a diverse set of reactions. Anantakrishnan was particularly conscious of the fact that reaction kinetics is one field where worthwhile research of a fundamental nature can be undertaken by an undergraduate department with the barest of equipment and facilities; and that the field is sufficiently challenging and eminently suited to bring the best out of a worker. The interpretations by Anatakrishnan of some of the results were unique and strikingly different from accepted concepts, they breathed a freshness even into problems which were presumed settled. For example, while it was taken for granted that the Westheimer mechanism was the pathway for the oxidation of alcohols by chromic acid, Anantakrishnan and Venkatasubramanian adduced evidences that this ran counter to many experimental facts and proposed an alternative hydride in abstraction mechanism. Another remarkable area of work, with Radhakrishnamurthy, was the kinetics of hydrolysis of diesters. Similar uniqueness is also evident in the interpretations given by Anatakrishnan on the solvent effects (including isotope effects) on reaction rates, particularly in the Menshutkin reactions and a number of oxidation processes. By his penetrating analysis he was able to generate evidence for the role of intermediate, transient oxidation states in reactions by the effect thereon of complexing agents.

Reaction kinetics by no means remained the only field to engage Anantakrishnan's endeavours. He believed in improvisation and could always suggest feasible means to

investigate any type of problem. It is to his credit that he, with his associates, constructed totally indigeneously a high-precision heterodyne beat instrument at Madras Christian College which became the first centre in India to take up fundamental work in dipole moments. He diversified into work on magnetic properties, UV,IR and Raman spectra in relation to molecular structure. His findings, extensively reported in over 100 publications, demonstrate his incisive analytical ability, his encyclopaedic knowledge of the relevant chemical literature and, above all, his style of establishing the scientific truth in simple, direct language.

Anantakrishnan's contributions to the cause of science education and research have, no wonder, been universally appreciated. He was elected a Fellow of the Indian Academy of Sciences in 1938, a Fellow of the Royal Institute of Chemistry (now the Royal Society of Chemistry) in 1951, and to the National Academy of Sciences in 1967.

Anantakrishnan had, over the period of more than thirty years of academic career, trained a large number of scientists many of whom are recognised leaders in their various fields of research today. The greatest tribute to Anantakrishnan came from these students who proudly acknowledged their debt to him on August 24, 1968 when he was felicitated on the occasion of his 60th birthday at Madras Christian College. The Anantakrishnan Lecture Endowment was instituted in the College on that occasion. Prof CV Raman, who had influenced Anantakrishnan's scientific career considerably, said in his message, "*As a professor at his college in Tambaram he has been a source of inspiration to a whole generation of students and has helped to create in their minds an appreciation of the significance of research in any course of advanced scientific studies. As a Fellow of the Indian Academy of Sciences he has rendered most valuable service to the Academy and has been a source of strenght to it*". Prof CK Ingold had this to say in his message, "*It has been an outstanding pleasure and interest to me to follow over the past 30 years the rising importance of his work and influence for the good of science and the good of India. I am sure that his work and influence will continue and even increase in value*".

Anantakrishnan was a firm believer in maintaining high academic standards; he realised the importannce of undergraduate as well as postgraduate education in the Indian context, and the role that the Universities have to play. He was all for periodic revision and upgrading of syllabi, but was against the idea of change just for the sake of change, any change should be well planned out in advance and implemented with constant monitoring of its progress, incorporating modifications as may be indicated by any un-anticipated shortfalls. He disliked unnecessary experimentation with curricula where one would be dealing with young, susceptible minds with their future at stake. He decried dogmas whether in scientific reasoning or in academic planning. He was forthright in putting forward his own views, however, much they might displease others. Thanks to his stand and efforts on these matters at various academic bodies, one sees today a vastly improved situation. Nevertheless he used to feel that there was scope for much further improvement.

Anantakrishnan fervently desired that the standard of science teaching in our colleges should keep pace with the cascading developments in the various fields. He insisted on the dictum that a teacher should never cease to learn. He wanted teachers to innovate and to improvise, all the time keeping in mind the fact that the most important aspect at any level of teaching is clarity. His own lectures were characterised by an economy of words but with a wealth of ideas. He belonged to that fast-vanishing category of teachers who believed that the student, whether at the graduate or at the research level, should be taught to think, provoked to raise questions and encouraged to seek the answers by himself. He detested 'coaching' which destroys the intrinsic abilities of the student. He would become very indignant at the thought of the existence of bazar notes and guides which have permeated every level of education today. Anantakrishnan believed that some research activity should be incorporated at the higher levels of education as an integral part. For him, in the best of the Raman tradition, excellent research findings need not require sophisticated, costly equipment but the right kind of training and development of skills of observation and interpretation.

Honour and fame never went to his head but sat lightly on him as if to adorn him. He led a simple life to the end. He was eminently approachable to the scholars and the novices alike. He believed that a scientist is an ethical person who should maintain high standards in both personal and professional life. He practised what he preached. As a teacher, a guide or an educationist, Anantakrishnan could inspire everyone by his mere presence. Such were the magnitude of his personality and the intensity of his commitment to his calling.

Anantakrishnan sustained a lasting interest in the progress and welfare of his past students. For any of them to meet him in his later days, it was always a touchig experience.

Anantakrishnan's wife, Smt Rajalakshmi, was the daughter of Sri MK Ranganathan, a well-known Engineer in the Government of Madras who subsequently became the first Director of the Madras Institute of Technology. Anantakrishnan's wife predeceased him in 1956, leaving behind a young family of three daughters and two sons. The karmayogi that he was, Anantakrishnan was not daunted by this personal calamity and brought up his children all by himself in the most exemplary manner. Today his children, who are all well-settled, cherish his memory with great affection and reverence, as do the many students moulded by him.

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VISHNU VASUDEV NARLIKAR

(1908 - 1991)

Foundation Fellow

VISHNU VASUDEV NARLIKAR was a pioneer Relativist in India, a great teacher of mathematics, a popular orator on scientific topics and a very warm personality.

FAMILY BACKGROUND AND EDUCATION

He was born on 26th September 1908 at Kolhapur, the capital of an erstwhile princely state in Maharashtra. The family in which he was born was a very devout and religious family. His father Vasudev Narlikar was a religous scholar and his sermons on Bhagvat Puran were heard with rapture by large audiences. This religious strain was also seen in the character of Vishnu Narlikar and in his remarkable fondness for reading Sanskrit books and books of all religions. His wife, Mrs Sumati Narlikar is a Sanskrit Scholar.

He had his primary and high school education at Kolhapur. In school he was known as a very bright student. At the matriculation examination (1924) of Bombay University he won the Sir Le Grand Jacob Scholarship. The financial position of the family was not that good, but he was able to persue higher education with the help of scholarships he won. He went to Bombay in 1924 and joined the Elphinston College and the Royal Institute of Science. His college career was of great distinction. At the BSc (Hons) examination (1928) of Bombay University, he stood first class first with record breaking marks in mathematics. He went to England for higher studies. Financially he got a loan scholarship for this from JN Tata Endowment and from Kolhapur State. He was also awarded Sir Mangaldas Nathubhai Travelling Fellowship of the University of Bombay. He joined Fitzwilliam House of Cambridge University and passed the Mathematics Tripos II in 1930 and became a B* Wrangler. At this examination he stood first in Astronomy and got Tyson Medal.

He began his further studies under Professor HF Baker and attended his lectures on "Brown's Lunar Theory". In July 1930, he began work on Liapounov's famous paper on rotating fluid bodies. In September 1930 he gave a written review of Liapounov's

method, work and achievements. Professor HF Baker was too busy with other work and he sent the review to Professor J. Larmor, under whose guidance Narlikar was to work further. On the basis of this work he was awarded Sir Isaac Newton Studentship for one year in the first instance. A year afterwards the award was made for three more years. He had already begun work under Prof AS Eddington on Relativity and Eddington's Fundamental Theory. The first ten items of the list of publications refer to this period at Cambridge where he was awarded a Rayleigh Prize in April 1932 for distinguished research work.

In May 1932 he returned to India with the intention of resuming his work at Cambridge for two more years from October 1932. However in August 1932 he was offered excellent opportunities of teaching and research by the Banaras Hindu University. He accepted the offer and then ended his formal education and research training and he began his professional academic career at the age of 25. He taught at BHU for 28 years till 1960. After a stint at Rajasthan Public Service Commission (as its Chairman) for six years he became Lokmanya Tilak Professor of Mathematics at the University of Poona and retired in 1973.

Research Activities

Narlikar was a pioneer relativist in India. After joining BHU he had several student collaborators working with him in General Relativity, Gravitation and Cosmology. Soon this evolved into an active research school at Banaras and later at Poona. Some outstanding work was carried out at his school is described below. (Figures in brackets refer to serial number of the paper in the list of publications given at the end.)

In 1947 Dr KR Karmarkar had produced a number of interesting papers on the problems of equivalence of metrics but the two papers which received considerable attention were joint papers with Narlikar on the curious solution of Einstein's field equations (47) and on the fourteen scalar invariants of a general gravitational metric (58). As regards the latter, Professor AR Prasanna, a student of the Poona school writes.

"In 1922 the noted mathematician TY Thomas had proved that in Riemannian manifold of 4 dimensions only fourteen independent curvature invariants can be constructed. But the explicit construction of these fourteen invariants using the curvature tensor and the Weyl tensor and the metric tensor was given only in 1946 by Narlikar and his student Karmarkar. However, as this was published in the *Proceedings of the Indian Academy of Sciences,* it was not known outside where the credit had been given to Gehenau and Debever who did the same work in 1952. In fact I had the privilege of pointing this out to Prof Gehenau in 1972 at the Dirac Symposium and he himself suggested that these invariants should be called Narlikar-Karmarkar invariants. One hopes that this will go into the literature and the credit due to Professor Narlikar is given".

About this time Einstein's Unified Field theory of Gravitation and Electromagnetisim was out. Dr Ramji Tiwari examined the nature of interaction between the electromagnetic field and the gravitational. Very lengthy calculations were carried out independently by him and Professor Narlikar and several papers explaining the character of the interaction came out in 1948-49 (62, 63, 64).

Dr PC Vaidya, while working at Banaras had obtained the relativistic solution of a non static mass in 1943. A few years later Narlikar and Vaidya published some papers jointly on the electromagnetic effects of such fields (53, 54). Vaidya's solution (1943) has now become famous in general relativity.

After 1950, Narlikar and KP Singh commenced a series of joint investigations on physical significance of several metric invariants. Among several publications of this period may be mentioned the one on the role of three index symbols in general relativity (67) where an analysis is made of the indeterminateness implicit in the coordinates of general relativity and a new derivation of the inverse square law is given.

Dr BR Rao, another student of Professor Narlikar at Banaras, worked on the derivation of the equations of motion from the field equations themselves. His important results have been reported in a joint paper published in 1955 (69). This was followed by several other papers including the one on the calculations of the motion of the perihelion of Mercury in 1959.

At the University of Poona (1966-1973) several students including Professor AR Prasanna, Prof N Dadhich, Dr RS Tikekar and Dr PP Kale worked on problems arising out of Petrov classifications, generalised field equations, spherically symmetric metrics and their curvatures etc.

It will be seen from the above that the main research areas developed by the Banaras and Poona schools were :

(i) Exact solutions of Einstein's equations of general relativity.

(ii) The solutions of the unified field equations of Einstein and Schrodinger.

(iii) Equations of motion as derived from field equations.

(iv) The fourteen scalar differential invariants of the Riemannian metric and their physical significance.

(v) The geometrical and physical properties of metrics satisfying Einstein's field equations.

About 20 young men were associated with him in research in these areas during 1932-1973. Most of them got doctorates, but what is more important, many of them continued their research and formed their research groups. Thus a small seedling planted by Narlikar at BHU in the early thirties has now flowered into a big banyan tree.

A Conscenscious Teacher :

At Banaras Narlikar had opportunities to learn and teach many topics in mathematics such as (1) Modern Algebra (2) Groups, characters and their applications (3) Wave Mechanics (4) Spinors and their applications (5) Hilbert's space and quantum mechanics (6) Stellar structure as it developed after 1940 etc.

For him teaching and research were complementary. He could best be described as a teacher mathematician. A teacher-mathematician-more than a teacher and a mathematician-is one who uses teaching methods in mathematical research and research methods in mathematics teaching. His philosophy of teaching can best be judged from his writings and lectures. At one place he has stated, 'When I started teaching mathematics at Banaras, I was more self critical and I found that there were so many gaps and voids in my understanding of the topic I taught'. Elsewhere he has pointed out the reasons for these gaps, 'Mathematics of the eighties is going to be different from that of the seventies just as the mathematics of the seventies was different from that of the sixties. The mathematics that I learnt as a student differed very much from the mathematics, I was called upon to teach'. He therefore concluded. 'The first lesson that I learnt was, one cannot be a good teacher, a successful teacher, without being always absorbed in the research topics concerned with his lectures'. His mathematics classes were always enjoyable and his popular talks on mathematical topics were always well appreciated because of his research oriented method of presenting a topic.

It was mentioned earlier that Narlikar used teaching methods in guiding mathematical research. To illustrate this, the best way seems to be that the present author recounts his personal experience as Narlikar's research student in 1942-43. Incidentally that will bring into focus another trait of this teacher– mathematician – his transparent academic integrity.

"Narlikar suggested that I should work on the problem of the gravitational field of a radiating star. We began working on the problem together. We enunciated the problem in the following manner, to calculate the gravitational field of flowing energy by comparing the radiation flowing out of a star with the flow of a fluid. For such a comparision, the current belief was that, if the fluid were to represent radiation, its density should be three times the pressure. We started our work on the basis of this understanding but found it difficult to derive any tangible conclusion. Once, during discussion, I suggested that, instead of assuming the pressure density relation, we might work on the basis of velocity, if the fluid is to represent the flow of radiation the fluid velocity must be assumed to be the velocity of the radiation. i.e. the velocity of light. Professor readily agreed and said, Yes, that is what we should have done!' We recast our calculations to suit the new assumption and at that very sitting Narlikar derived the first tangible equation. This sitting ended on a happy note and with the hope that I would be able to derive the other two equations.

In describing teaching methods, Narlikar had once said, 'It is necessary to intersperse a lecture with periods of silence to allow the students time to ponder'. He used this teaching method in my case. Left with the task of working out the remaining equations of our problem, it so happened that I could not see him for two weeks (normally I used to meet him twice every week) - thus providing me 'time to ponder'. Well the net result was that not only did I derive the other two equations of the problems but solved the three equations simultaneously and came up with the complete solution of the problem. At that stage I was overjoyed because, within eight months of beginning research, I had with me a solution of an outstanding unsolved problem. It is only now that I realize how much of this was due to the teaching method of 'providing time to ponder' so effectively used by Professor Narlikar.

We wrote down the final solution in the form of a paper for publication. Narlikar put down only my name as the author of the paper. The usual practice is that the professor who suggests the problem becomes the first author of the paper and the student's name is included as a joint author. But Narlikar did not follow that routine because the main idea which provided a breakthrough in the work was provided by me and so he gave full credit to me. Today, when I think about it, I realize that Narlikar very well knew the importance of this solution, and even if he had just added his name as a joint author, the solution would have been known as 'Narlikar's solution'. At that point of time I was too young to understand such things. The solution known today as 'Vaidya metric' could easily have been credited to his name if he had so desired and that would have been in accordance with prevailing norms. But Narlikar preferred to stick to purer academic norms and decided that when the principal idea leading to the solution came from Vaidya the credit of the work must go to him. What a fine example of academic integrity.

Epilogue :

Narlikar was the founder fellow of all the three science academies in India. He was a fellow of the Royal Astronomical Society. He was president of the Calcutta Mathematical Society (1958-60) and of the Indian Mathematical Society (1981). But above all, he was revered by the present generation of Indian relativists as Grandpa Narlikar.

As mentioned earlier his wife Mrs. Sumati Narlikar is a Sanskrit scholar. A book containing lectures delivered by her in Sanskrit has been published under the title Sumati Darshanam.

They have two sons, Jayant and Anant. Dr Jayant Narlikar is a well-known astrophysicist and science fiction writer in Marathi and is currently director of the Inter University Centre for Astronomy and Astrophysics. Dr Anant Narlikar is a deputy director of National Physical Laboratory in Delhi.

Professor Narlikar spent his retired life with his son Jayant. He died at Pune on April 1, 1991 due to old age.

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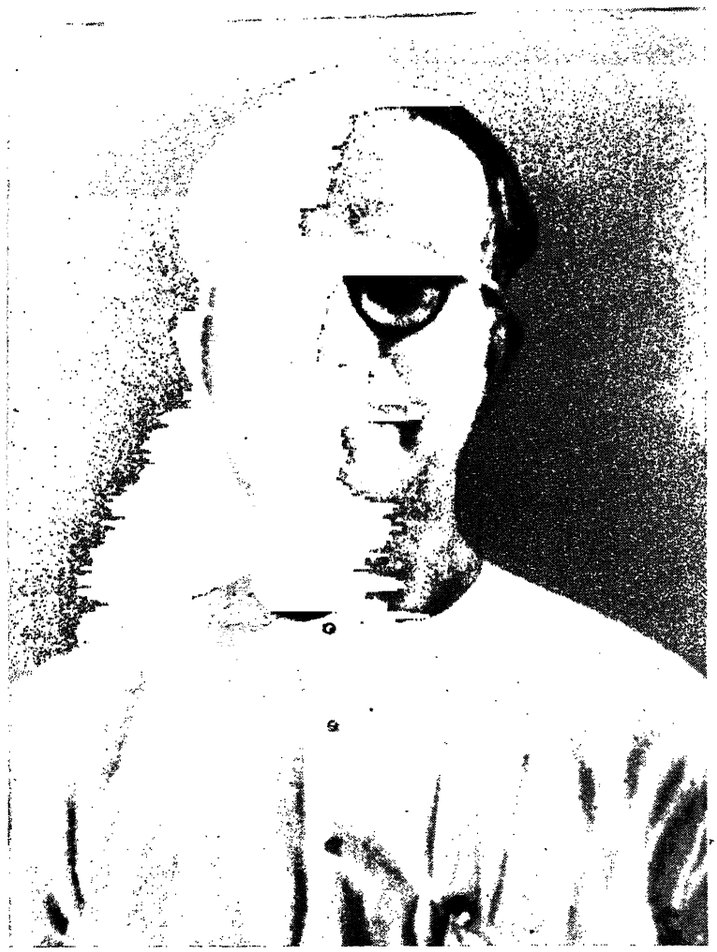

B. N. Ghosh

BHUPENDRA NATH GHOSH

(1900 - 1988)

Elected Fellow 1942

BIRTH AND PARENTAGE

BHUPENDRA NATH GHOSH was born in Ghargoal village of Hooghly District, W Bengal in the year 1900. Exact date of his birth was not in record but in all probability he was born either in March or April of that year which will agree with first day of Chaitra month of the year 1306 according to the Bengali Calender. His father Ram Chandra Ghosh had four sons,namely Sarat Chandra, Nrishingha Chandra, Jnan Chandra and the youngest one Bhupendranath. Besides this, he had one sister, Sarojurani Sarkar, who was eldest in the family. The name of his mother was Monorama Devi. His father was owner of a mica mine and in connection with this job he lived in Bihar for certain period of time. Jnan Chandra, his brother was a renowned scientist, educationist and administrator who served as the fifth President of the Indian National Science Academy in 1943-44. The Academy at that time was known as National Institute of Sciences of India.

EDUCATION

Bhupendranath was educated in Raja Ram Mohan Roy Seminary, Patna from where he passed the matriculation examination of the Calcutta University with distinction. Jnan Chandra at this time was busy with his higher studies and research in physical chemistry at the University of Calcutta. As a school student, Bhupendranath frequently visited his brother at Calcutta where he also met MN Saha, Satyendra Nath Bose and others who were batchmates of his elder brother. They frequently explained to him the practical and creative aspects of basic science and mathematics. All these made great impact in the mind of young Bhupendranath and no wonder he decided to become a scientist in future.

After completion of school education, Ghosh came to Calcutta and took admission in the Scottish Church College and subsequently took transfer to Presidency College. From here, he obtained first class honours degree in Chemistry from the Calcutta University and in 1922, became post-graduate student in Chemistry in the University

considerable guidance from Jnan Chandra Ghosh who also influenced him to select physical chemistry as his special subject of study in the post-graduate science course.

In the Science College, young Bhupendranath came in contact with Acharya Prafulla Chandra Ray, a scientist who inspired many Indian scholars to scientific research. By this time, Jnan Chandra Ghosh made a noteworthy contribution to electrolytic theory from the Calcutta University. Prof JN Mukherjee also established a well-known colloid school of the Calcutta University. As a student of Professor Mukherjee, Prof BN Ghosh became attracted to this special branch of physical chemistry. In 1924, he passed his MSc examination with thesis in physical chemistry standing first in the merit. In 1926, Professor Ghosh received Guruprasanna travelling fellowship and joined the University College of London where he started his research with famous Professor FG Donnan. His fields of research were both colloids and proteins. This dual interest had been well-maintained by Professor Ghosh, throughout his life. The writer and many other associates can still recall some of the exciting moments in the Physical Chemistry laboratory of the Calcutta University in 1950, when snake dealers would come to take out venomous cobra one by one and squeeze out the venom for identifying venom proteins and enzymes which were used for biochemical research.

Professor BN Ghosh received DSc degree from the University of London and returned to India in 1930. In London, he developed deep friendship with Professor Biresh Chandra Guha, the renowned Indian Biochemist of India who was the founder of the Division of Biochemistry in the Applied Chemistry Department of the Calcutta University. This friendship was maintained until the death of Professor Guha.

Professional Career and Membership

On his return to India, Dr BN Ghosh first worked as a research scientist at the Malaria Research Institute, Kasaoli, UP and then in 1934 became PC Ray Fellow in the Department of Pure Chemistry, Calcutta University. After a year, Bhupendranath was appointed as Lecturer in the Department of Applied Chemistry and he continued his research and teaching in this post for thirteen years. During this period, he in association with a large number of students carried out extensive research on the biochemical aspects of snake venoms mainly of Indian and Asiatic origin.

He was appointed Reader in the Department of Pure Chemistry in 1947 and Palit Professor in 1953 and became the Head of the Department of Pure Chemistry in October, 1961. He was elected the Dean of the Faculty of Science, Calcutta University and nominated as the Vice-President of the Council of the University College of Science. He is a fellow of the National Institute of Science of India (later known as Indian National Science Academy) from the year 1942. He was twice elected Vice President of the Indian

Chemical Society. For a number of years, he was also Honorary Treasurer of the same society and Member of the Council for several terms. He was a member of the Advisory Board of the International Journal "Toxicon" and a member of the Chemical Research Committee, CSIR, New Delhi for some period of time. He also served as Honorary Advisor of the Bengal Immunity Research Institute, Calcutta for certain period of time.

He retired formally from his service in 1965 but his association with the Calcutta University continued for several years as a Retired Professor of Chemistry under the University Grants Commission as well as under CSIR. Even after formal retirement, at the age of 65, he was active in research for twenty three years upto the last days of his life. He published nearly seventy five papers during this period only on varied topics of physical chemistry. His last paper was published in the Journal of Indian Chemical Society on 26th May, 1988, just two months before the death.

CONTRIBUTION TO SCIENCE

Professor BN Ghsosh along with a large group of co-workers published nearly 180 original research papers in three distinct scientific fields such as physical chemistry, biochemistry and medicinal chemistry. His special areas of interest were (a) colloids, emulsions and electrokinetic phenomena, (b) gels, polyacids and proteins, (c) adsorption and adsorbed monolayer, (d) colloidal electrolytes, electrode processes, kinetics (e) theories of electrolytes, (f) snake venoms, immunochemistry and clinical biochemistry. In each of these fields, he published number of papers which contained clear ideas and new design of experiments. Outline of these valuable works will now be discussed in brief.

(a) Colloids, Emulsions and Electrokinetic Phenomena

As a student of Professor JN Mukherjee, the first paper of Dr BN Ghosh (1924) was published in the first volume of the Journal of Indian Chemical Society on the ion-antagonism aspects of coagulation of stable hydrophobic colloids by mixture of electrolytes. At this time, Ellis at the suggestion of Professor FG Donnan in the University of London carried out experiments on oil-water emulsion and had come to the conclusion that a suspensoid coagulates when its zetapotential (electrokinetic potential) is reduced to a certain critical value which is not zero. Ghosh at this time (1926-29) joined the laboratory of Donnan at London and carried out experimental research on the stabilities and coagulation of manganese dioxide, stannic oxide and arsenic sulphide sols and bentonite suspension by the addition of electrolytes of various types and other additives. Ghosh (1929) measured zetapotential of metallic oxide and arsenic sulphide sol in the presence of various inorganic electrolytes. At the point of colloid coagulation, the results with oxide sols showed existence of critical zetapotential but it appeared to be nonexistent for arsenic sulphide colloid. In 1946 onwards, Ghosh re-examined this problem again with a large group of co-workers at the University College of Science, Calcutta. From a

study of electrophoresis and electro-osmosis of vanadium pentoxide colloid, Ghosh *et al* (1951) gave a fine experimental support to the Smoluchowski equation for electrophoresis of microscopically viscible particle against Huckel's equation for the same. This was also a good support for Henry's more general theory of electrophoresis.

It had already been suggested by other workers that when the electrolyte concentration in the colloid system forming the diaphragm is low, the Zetapotential (ζ) calculated from the electro-osmotic experiments using the Smoluchowski equation does not represent its true value (ζ) due to the tremendous effect of surface conductance of the solid particles forming the diaphragm. Ghosh and coworkers (1953) showed that the values of the bulk conductivity of the electrolyte present in the diaphragm during electro-osmotic measurement of colloidal systems at the equicoagulating concentrations of electrolytes of differenct valance could be brought into line with the theory of the critical zetapotential proposed originally by Ellis, if one assumes that a relationship between true and apparent zetapotentials exists in the form of equation (1).

$$\frac{\zeta}{\zeta\ \alpha} = 1 + 2\alpha \frac{K}{rS} \qquad \ldots\ldots \qquad (1)$$

Here K is the specific surface conductivity of the capillary of radius r equivalent ot that of the diaphragm. S stands for the bulk conductivity of the electrolyte and α, the diaphragm correction factor of Ghosh (1956) for packed medium.

On the basis of this fundamental theoretical approach proposed by Ghosh, two main lines of work started in his laboratory. In a series of papers, Ghosh and coworkers (1954, 1954-1961, 1963) first studied electro-osmosis through diaphragms of different materials like glass powder, cellulose, gelatin, hide and collagen, wool and examined all the similar data available in literature to show that the above equation can be used to correct for surface conductivity effect to get the true values of zetapotential. Ghosh (1955) also gave physical significance of his correction factor α which he showed to be equal to the surface area of the particle divided by the surface area of the capillary equivalent the pore per particle. The experimental and theoretical values of α had been compared by him critically.

Correction for surface conductance according to Ghosh (1955) for electrophoresis can be made using equation (2)

$$\frac{\zeta}{\zeta\alpha} = 1 + \frac{K}{rS} \qquad \ldots\ldots \qquad (2)$$

Here r is the radius of the particle moving under electric field.

For a large number of inorganic colloids, Ghosh and his associates (1954-1964) were also able to demonstrate that the value of true zetapotential at the equicoagulating point was constant for each sol and was independent of the valance of the counterion. This was true for slow as well as for rapid coagulation of colloids. Further, it had been clearly demonstrated for different sols that the critical zetapotential for coagulation of

colloids based on electro-osmotic and electrophoretic experiments were identical only when proper surface conductivity corrections were made using equations (1) and (2). Ghosh (1961) also believed that zetapotential of colloidal particle is a constant fraction of the total double layer potential at the coagulation state.

Ghosh in 1967 pointed out that conditions at many solid-liquid interfaces are favourable for the formation of a semiconducting layer of solid. The effect of this together with the specific surface conductance effect in the diffuse double layer on electro-osmosis and the zetapotential of particles forming diaphragm was mathematically analysed by Ghosh in this paper. In another paper published in the same year, he demonstrated on mathematical grounds how equation (1) valid for electro-osmosis could be converted to electrophoretic equation (2) when surface conductance effect was present.

Earlier in 1931, Ghosh *et al* determined the electrophoretic velocities of bacterial suspension in the presence of electrolytes, non-electrolytes and immune sera. With these experiments, they were able to measure the isoelectric p^H of leishmania tropica sensitised by immune sera to be 5.3, whereas in its absence the charge reversal of the bacteria could take place between pH 3.0 to 3.4. The isoelectric point of adsorbed bovine serum albumin was determined by Ghose *et al* (1962) after surface conductance correction and also the specificed surface conductivity for BSA was estimated by them.

In the case of slow coagulation of colloids by the addition of inorganic salt, Ghosh (1959, 1962, 1963) defined a quantity E which is the percentage of successful encounters of the particles for aggregation of colloids. He applied the relation thus obtained to explain the data on slow coagulation of selenium and gold sols studied on the basis of ultramicroscopic counting. He also derived an original equation for the rate of slow coagulation studied by the spectrophotometric method. This equation was found to agree with the data for slow coagulation of arsenic sulphide, ceric oxide, thorium oxide and titanium oxide sols.

Ghosh *et al* (1952, 1953) measured extensively non Newtonian viscosities of emulsions stabilised with cationic and anionic soaps. Richardson's equation was modified by them which thus fitted excellently with the experimental data. These investigations also indicated that the phase reversal of an emulsion should be accompanied by an abrupt change in the emulsion viscosity. Ghosh and coworkers (1954) showed that the interfacial films for soap-stabilised emulsions are unimolecular in nature. From the simultaneous measurement of interfacial tension of the oil-water system and extents of adsorption of various soaps per unit surface area of the emulsions formed by these oils dispersed in the aqueous phase, Ghosh *et al* were able to show the experimental validity of the Gibbs adsorption equation. In 1931, Mooney has shown that the electrophoretic velocity of fine emulsion droplets increased with increase of their particle size. Ghosh *et al* (1955) explained this variation quantitatively on the basis of surface conductivity equation (2). The specific surface conductivity K of such oil-water interface had also been estimated by them.

(b) Gels, Polyacids and Proteins

The effects of pH and temperature on the rate of gelation of silicic acid were examined by Ghosh *et al* (1954, 1963). They also derived an equation relating time of gelation of silicic acid with pH and silica concentration. It was also shown by them (1951) that there exists a critical zetapotential for gelation to occur at the same rate by the action of electrolytes of varying valency.

The basicity and formation of iso and hetero-polyacids were studied by Ghosh and coworkers (1962, 1963). The complex systems studied were silicic, molybdic, vanadic and tungstic acids. The basicity of these acids were determined by electrometric titration based on the idea that these acids remained in condensed form in solution. The self-condensation polymerisation of silicic and tungstic acids evidenced a third order reaction among the hydroxyl groups of the acid concerned and second order in the case of vanadic acid. A satisfactory mechanism had been offered for each system (1962, 1963). Optical properties and molecular weight determination by following the change in scattering of light and viscosity were undertaken during the process of their polymerisation. Formation of heteropolyacids between tungstic and molybdic acids, vanadic and a-hydroxy acids and vanadic and phosphoric acids were also studied (1962, 1963). Some interesting results on the composition of the complexes were obtained and mechanism of their formation and properties were realised.

As a student of Donnan, Ghosh always maintained deep interest in the physical chemistry of proteins. He studied earlier (1927, 1928 and 1931) the swelling and electric charge of gelatin and fibrin (1940). He demonstrated that so called "second minimum swelling" was not related to a decrease in electric charge. Only the first minimum represented the isoelectric swelling. Later, Ghosh *et al* (1957, 1958) studied electro-osmosis and swelling of tanned and untaned hide collagen. The mechannism of tanning by different agents was ellucidated from the isoelectric point of different leathers, determined unequivocally by electro-osmosis through the actual leather used as diaphragm. The shrinkage temperature of hide and leather was shown to be directly related to swelling of the modified proteins.

(c) Adsorption and Adsorbed Monolayer

As a physical chemist interested in surface phenomena, Ghosh was always interested for the study on the adsorption of surface-active substances on solid-liquid, liquid-air and liquid-liquid interfaces. Earlier (1935-37) he studied the properties of antigens adsorbed on antibodies and derived many biologically important conclusions. In 1937 with De, he made an attempt to separate and isolate different fractions of proteins present in cobra venom using various adsorbents at different pH. He and his associates earlier (1946) showed that quinine can be adsorbed significantly on charcoal, fuller's earth and kaolin so that it can be extracted from its solution by different adsorbents and can be subsequently eluted by using suitable solvents. He also studied (1931) adsorption of

hydrogen ions by gelatin and albumin on the basis of some fundamental experimental approaches.

Ghosh *et al* (1952) studied the adsorption of various organic acids on hydrated stannic oxide surface in the presence and absence of neutral salts and some co-relations between adsorption capacities and structure of different organic acids. Adsorption of ions by hydrated manganese dioxide in relation to its electric charge and pH had been examined by him (1951).

In 1954, in association with Rakshit, he studied adsorption of sodium laurate at the emulsion droplets of xylene-water interface. The applicability of the Gibbs adsorption equation was examined in the light of this adsorption data after combination with results on interfacial tension measurements.

From 1966 to 1972, Ghosh became interested in the study of the properties of adsorbed monolayer of ionic surfactants at air-water and oil-water interfaces based on the data obtained from boundary tension measurement. On the basis of Langmuir theory, he derived a fundamental equation for the adsorption of an electrically neutral solute at the air-water and oil-water interfaces. Using this equation, an expression for distribution of solute between two immiscible liquids was obtained whose form was consistent with Nernst distribution law. Application of the isotherm obtained by him was extended to the adsorption of surface-active electrolyte at interface of oil and water. The plot of surface pressure (π) versus surface area (A) per adsorbed molecule obtained from the experimental measurement were found to fit the Ghosh equation satisfactorily. Appropriate corrections for the effect of electric charge in his equation was also introduced by him in appropriate manner. From the measurement of interfacial tension (γ)at different concentrations of the stabiliser in bulk, the amount of surfactant absorbed per unit surface area was calculated by Ghosh *et al* (1966). From the electrophoretic mobility measurement, the values of zetapotential of the oil droplets were simultaneously calculated with a view to ascertaining its dependence on the extent of its adsorption.

Ghosh *et al* (1968) modified their adsorption equation after consideration of mutual electrostatic repulsion of the long-chain ions at the interface. The extent of validity of these equations at oil-water interfaces had been examined on the basis of experimental data. The surface pressures at the oil-water interface calculated by Davies equation and that derived by Ghosh at a given concentration of the surfactant were found to be almost equal to each other (1969). Extents of adsorption of the surfactants CTAB and SDS calculated from the boundary tension measurement using the Gibbs adsorption equation were also found by Ghosh and workers (1969) to be identical with those analytically obtained by emulsion technique. Their data were also found to fit both Langmuir and Freundlich adsorption equations.

Ghosh (1970) expressed the view that cohesive force exists between the CH_2-groups of the neighbouring long-chain ions adsorbed at an oil-water interface and he cited experimental evidence for it. He also opined that under suitable condition, long-chain α-aminoacids at oil-water interface may exist as ion-pairs of zwitter-ions, cations or anions.

Possibility of existence of Vander Waals type of attraction between the ion pair of zwitter ions and the cations or anions of a long-chain amino-acid at the oil-water interface was suggested by him (1970). In 1971, an equation for surface pressure involving cohesive force at oil/water interface was derived by Ghosh for ampholytes and weak electrolytes. The origin of the cohesive force had been attributed to the dipolar character of the zwitter ions of stearyl phosphoric acid. The equation was found to fit the experimental data satisfactorily.

(d) Colloidal Electrolytes, Electrode Processes, Kinetics

In 1973, Ghosh derived equations based on theoretical grounds to account for the osmotic pressures of sols made up of colloidal electrolyte gum arabic under conditions in which the concentrations of gum arabic and that of diffusible ions are varied. This derivation of the relation involves an interpretation of the Donnan theory of membrane equilibrium. The derived equation was found to agree well with experimental data. Based on this approach, equations have been further derived by him connecting pH of the suspension with ratio of the unneutralised to neutralised portion of the clay acid. The derived equation agreed well with the experimental data on titration of clay acids by alkali.

To account for the concentration of colloidal electrolyte on the pH of the suspension due to the Pallman effect, Ghosh (1974) derived a relation which was found to agree with experimental data of neutralisation of gum arabic and polyacrylic acid by alkali. The pK_s of the two acids were found to be 3.03 and 4.77 respectively. The experimental observation of Scatchard that the pH of bovine serum albumin (BSA) increases with increasing concentration of an added neutral salt had also been explained by Prof Ghosh (1975) on the basis of this derived equation. The extent of binding of the H^+ ions by BSA had also been accounted by him and the pK value of the COOH groups evaluated by this newly derived equation is 3.18.

With the assumption that the Glass electrode is almost completely covered by adsorbed monolayer of protein and on the basis of the proposed theory of colloidal electrolyte, equations had been deduced by Ghosh (1976) which could quantitatively account for the rise of isoionic pH of BSA caused by the addition of neutral salts without assumption of anion binding. Value of pK of the proton donor in certain pH range of protein has also been evaluated to be 6.18.

Combining the proposed equation of Ghosh (1976) for the varitation of specific conductivity of a colloidal electrolyte with its concentration with the Smoluchowski equation for electroviscous effect, relation had been deduced by him (1976) which accounted quantitatively for the variation of $\eta_{SP/C}$ with c of a colloidal electrolyte in the absence as well as in the presence of an added strong electrolyte. Here η_{SP} stands for specific viscosity or the colloidal solution of sol concentration c. The relation thus derived was found to fit the measured viscosity data for colloidal electrolyte, sodium thymonucleate,

sodium salt of gum arabic acid and monodisperse polystyrene lattices prepared by emulsion polymerisation. Later on, Ghosh (1977) modified Smoluchowski electroviscosity equation by taking into consideration the contribution of the ampholyte molecules in the specific conductivity of the solution. Some of the advantages of the modified equation and those which may follow from it had been subsequently discussed.

The constants associated with modified Smoluchowski electroviscosity equation had been evaluated by Ghosh (1978) from the experimental data. Ghosh also showed that the same electroviscosity equation in modified form can be derived from Booth's electroviscosity equation on the basis of certain assumptions. It had also been shown how the primary electroviscosity effect varies with the concentration of colloidal electrolyte in the sol under different conditions.

Combining Smoluchowski electroviscosity equation with Ghosh's equation to account for variation of specific conductivity of colloidal electrolytes with dilution, Ghosh (1979) derived an original equation which was found to be in good agreement with observed experimental data of polymethylmethacrylate sol.

Earlier in association with Prof BC Guha, Ghosh in 1935 measured the transference capacity of vitamin B in aqueous solution and also studied behaviour of oxytocin solution during electrodialysis.

In 1951, Ghosh and coworkers prepared two phase lead amalgam electrodes suitable for estimation of Pb^{++}, Ba^{++} and $S\bar{O}_4$ from the aqueous solutions of their salts mixed with alcohol by the use of potentiometric titration. The electroplating surfaces of non-conducting materials with copper and nickel had been made successful by the research group of Ghosh (1951).

Kinetics of oxidation of mandelic acid by ceric salts had been studied by Ghosh and coworkers in 1963. The oxidation was shown to proceed through the initial formation of an activated complex and subsequently through free radical mechanism.

(e) Theories of Electrolytes

In 1980, Ghosh published an original paper on the modification of the limiting and extended Debye-Huckel equations for the activity coefficients of strong electrolytes valid for aqueous solution. Ghosh actually included the activity coefficient terms in the Boltzmann distribution equations for cations and anions in solution. Using this modification, expression for Debye-Huckel reciprocal thickness κ is modified to the form.

$$\kappa = \left[\frac{4\pi e^2 \Sigma n' f^0}{DkT f'}\right]^{1/2} \qquad \ldots\ldots \qquad (3)$$

where f' and f^0 are activity coefficients for electrostatic potential ψ and zero respectively and e, D, T and k are electronic charge, dielectric constant, absolute temperature and

Boltzmann constant respectively. Also $(n')^2$ stands for [(n+) (n–)] where n+ and n- are concentrations of cation and anion respectively in the volume element close to the central positive ions. Using Donnan theory of membrane equilibrium, values of f^0/f' can be estimated in terms of electolyte concentrations existing within the ion atmosphere and in bulk regions of the aqueous phase. Debye Huckel equation with this kind of modification will assume the form,

$$- \log f = \left[\frac{p B}{(A)^{1/2}} \right] \left[C^{1/3} - C_0^{1/3} \right] \quad \ldots \quad (4)$$

where f is the activity coefficient of the electrolyte at concentration C in normality and C_0 is constant at constant temperature. Values of p is unity for uniunivalent electrolyte and 8 for bibivalent electrolyte. Values of the Debye-Huckel constants can be estimated numerically. The modified equation had been subjected to test using the data available in literature on HCl, NaCl, KCl, $CuSO_4$ and $ZnSO_4$. In 1982, Ghosh deduced similar expression for activity coefficient of uni-bivalent electrolyte. The fitting of the experimental data to the linear form of the cube root equation is quite satisfactory in all cases.

On the basis of the concept thus proposed in 1982, Ghosh (1981, 1983) formulated equations for the equivalent conductivity of the solution of strong electrolytes of 1:1 and 2:1 types. Fitting of the conductivity data in the derived cube root equation for KBr, NaCl, HCl and $CaCl_2$ appears to be very satisfactory. Also this derived equation had been shown by him to be of the same cube root form as that formulated as early as in 1917 by his elder brother Sir JC Ghosh.

Ghosh (1982) had further improved his equation for the activity coefficient by combining it with that derived by Glueckauf to account for the effect of hydration on the activity coefficient of the ions. The data available on HCl, LiCl, NaCl, KCl and CSCl fit satisfactorily to this newly derived equation of Ghosh.

Ghosh (1985) had introduced his modified expression of kappa including the effect of ionic hydration into the Onsager-Fuoss equation and thus he deduced expression for the diffusion coefficient D containing terms involving cube root and first power of concentration. This equation fits the experimental data for several electrolytes upto 0.1 (N) concentration. Ghosh (1983, 1986, 1987) also modified the equations derived by Jones and Dole on the viscosity of the electrolyte solutions on the basis of this concept involved in the cube root equation. An expression for B-coefficient of the modified equation was derived by him on the assumption that it should be identified with 2.5∇ of the Einstein viscosity equation where ∇ stands for volume fraction of the electrolyte in solution. The experimental test of his equation had been made on the basis of available data in literature. He was able to demonstrate that the B-coefficient thus modified varies linearly with $(h - \phi/18)$ where h is the hydration nunber and ϕ the apparent molal volume of the electrolyte in solution. He had also shown that the partial molal entropy of hydration of a strong electrolyte in solution varies linearly with absolute temperature.

In his last paper published in 1988, Ghosh derived equations for the potential energy and kinetic energy of the ion pairs on the basis of his approach based on equation derived by him. These energies do not vary with dilution so long as the effective diameter of each type of ion remains constant. Attempt had also been made by Ghosh to apply principle of quantum theory to the rotatory motion of the ion-pairs at different dilution.

(f) Snake venoms, Immunochemistry and Clinical Biochemistry

Snake venom expelled from poison gland of a snake is generally a yellow liquid 80-90 percent of which is water and the rest is composed of proteins, protein derivatives and some inorganic salts. The yellow pigments are the result of certain flavin compounds. Snake venoms are composed of a number of active principles such as neurotoxin, cardiotoxin, hemolysin coagulating factors cholinesterase and other enzymes.

Investigations of the isolation, characterisation and biological significance or the factors responsible for the paralysis of the nervous system due to bite by cobra snake (Naja Naja) were carried out by many workers. Ghosh (1967) showed that this factor consists of two active principles, one that causes paralysis of the respiratory system and other that causes failure of cardiac movement. Ghosh advanced the theory that the life of victim of cobra bite might be prolonged and in some cases be saved by resorting to artificial respiration at the proper time. Ghosh *et al* (1937) succeded in obtaining this toxin from cobra venom in much higher concentration by cataphoretic methods. They (1941) subsequently obtained highly purified respiratory toxin from cobra venom by means of fractional precipitation with salt and adsorption on the surface of tungstic acid followed by elution with barium chloride at pH 9.0 and treatment with a little sodium sulphate and methanol. The isoelectric point of the respiratory toxin thus prepared was higher than 9.4 (1967) which showed it basic character. Only about 15 percent of the toxicity of the purified respiratory toxin was inactivated when heated for 30 minutes at 90^0C. Addition of sodium bisulphate, zinc, hydrochloric acid, ascorbic acid and cysteine could inactivate the respiratory toxin to a marked degree.

Ghosh *et al* (1943) estimated the diamino acids, arginine, histidine and lysine of the purified respiratory toxin from cobra venom and concluded that proportion of these amino acids was very close to that found in thymus histone. Ghosh and co-workers (1967) noticed that fourteen band fractions separated when cobra venom was subjected to paper electrophoresis at pH 8.6. The fractions neutroxin hemolysin, cardiotoxin isolated from elution process were found to be almost homogeneous.

Ghosh and his associates (1942) studied in detail the effect of crude cobra venom and also purified respiratory toxin on the anesthetised cat and thus established the presence in cobra venom of a factor other than the respiratory toxin which acts only on the central nervous system. This active principle had later been named as cardiotoxin by Sarkar (1967).

The presence of a factor for hemolysis is an enzyme called hemolysin (lecithinase A or phospholipase A). Ghosh and De (1938) had separated the hemolysin fraction that had direct action on red cells of guineapig. They (1938) also worked on the purification of lecithinase from cobra venoms. Subsequently, De working in the laboratory of Ghosh succeeded in obtaining the hemolytic principle in crystalline state and its physico-chemical properties were thoroughly investigated by him.

It had earlier been established that acetyl choline is synthesized by the brain cells of animals. Ghosh and coworkers (1944) studied the effect of crude cobra venom and the purified respiratory toxin on the biosynthesis of acetyl choline by animal brain cells. From these studies, it had been concluded that crude cobra venom contains an inhibitor that affects significantly biosynthesis of acetyl choline by the brain cells of animals. Ghosh *et al* (1951) also observed that the anaerobic oxidation of lactate by pigeons brain in the presence of ferrocyanide was inhibited by the venoms of cobra, banded Krait and Russell's viper.

The presence of cholinesterase in cobra venom was observed by Ghosh *et al* (1938) who also noted that the respiratory toxin had no cholinesterase activity at all and only venoms of Elapidae possessed this activity. Chaudhuri (1967), an associate of Ghosh reported in a series of papers, the results of his studies on the physicochemical properties of purified cholinesterase.

Ghosh and his associates (1939) were able to purify the toxic fraction (neurotoxin) of Russell's viper venom using fractional precipitation method. They (1938) also studied the effect of reducing agents such as sodium bisulphite, cysteine, ascorbic acid, hydrogen sulphide and sodium sulphite on the toxic factor and found that it was appreciably destroyed by these chemical agents. Ghosh and his associate (1940) studied the reaction between Russell's viper venom and specific antivenin. They observed that a mixture of venom and antiserum in equivalent proportions developed maximum turbidity and hence the potency of the antivenin can be determined in-vitro by turbidity measurements.

The effect of the snake venom especially Russell's viper venom on the clotting of blood had been studied by many workers. Coagulating factor of Russell's viper venom was isolated and purified by Ghosh and coworkers (1939) using cataphoretic experiments. Ghosh and coworkers (1936-38) reported in a series of papers that cobra and Russell's viper venoms contained proteolytic enzymes that behaved almost like trypsin and several other peptidases.

The dried venoms of Bungarus type of snakes contain 90 percent proteins such as neurotoxin, hemolysin, cholinesterase enzymes. Ghosh *et al* (1938) had demonstrated that cholinesterase was present in the venom of Bungarus but not in Viperdae type of snakes. The research group of Ghosh (1936-38) produced experimental evidence to show that the venom of Bungarus contains proteolytic enzymes that might be identical to trypsin. These authors also observed that bipeptidase, tripeptidase and carboxypeptidase may also be present in this type of venom.

Ghosh also studied carefully the physical chemistry of several immunological reactions. The effect of electrolytes on the rate of flocculation of toxin-antitoxin mixtures of diphtheria and tetanus B had been earlier studied by him in 1937. In 1938, he and his associates examined the effect of pH, electrolyte and normal and immune serum addition on the electrophoretic velocity of leishmania tropica. The Danysz phenomena in stappylococcal toxin-antitoxin reaction had also been investigated by his research group (1937, 1939). In a review article, he had discussed (72), application of colloid chemistry to immunological reactions.

The chemical composition and spectroscopic properties of malarial pigment (haemozoia) was examined by Ghosh (1934) and he had also studied quantitative changes in the proteins of the blood sera of monkeys infected with malarial plasmodia. He had also developed method (1934) of determination of atebrine in urine since this drug was used earlier for treatment of malaria.

As a Man

Professor BN Ghosh was known amongst his friends, colleagues and students as simple and good man, a perfect Bengalee "Bhadralok". But he never accepted any compromise when it came to the question of principles. Professor Ghosh had strong nationalistic feeling. In his days in school, he came in contact with "Baga Jatin" the young freedom fighter who was later on killed during the fight with the British Raj. Professor Ghosh also believed in elevating the prestige of India in the scientific field. He made consistent effort to raise the standard of University education in India and the status of the Indian journals by publishing most of his research papers in Indian Journals. On his return from England, Professor Ghosh could have joined in a coveted Government post, but instead he joined the post of a Lecturer in the Calcutta University with a small salary.

As a devoted scientist, and as a sincere teacher, Professor BN Ghosh inspired a large number of students by his able guidance and stimulating discussions and by example of himself with a devotion to science and contempt to all kind of meanness. The facilities of research in India was very much inadequate when second world war started and Professor Ghosh during this period wrote "the War, the do-or-die movement of National Congress, the countryside arrest and most tragic famine that followed, naturally affected us and our research and teaching activities. However, we tried to do as much as we could do under the prevailing conditions". He refused to be the victim of any type of odd circumstances. Physical sickness, personal bereavement, old age, limitations in hearing and eye site, temporary paralysis could not divert his devotional single minded activities in science. Even after his retirement, he published many papers containing full of his original and new ideas. But he was never complacent of his scientific achievement and always wanted to learn from the experience of others in the field of science. After his full retirement, even if he did not have laboratories, he based his research on the

development of elegant scientific concepts and mathematical equations in the chemical fields of his interest. Everyday in the morning, like a school boy he sat in a charpai with his books, papers and pens and upto the evening with due break studied and wrote articles after articles. This was his regular routine life upto the age of eighty seven years.

The dealing of Professor Ghosh with his research scholars were always cordial and pleasant. As this writer recalls, one of our research colleagues once broke a microelectrophoretic cell. Professor Ghosh used to caution us everyday about handling this carefully as then it was very difficult to get a new one from abroad. So our friend had to go to Professor Ghosh with the broken cell and almost with a broken heart. However, to his astonishment, Professor Ghosh told him "Well, this means you are working very seriously" and gave him the only other spare and asked him to be careful again. Even if he noted that his scholars were behaving wrongly in the laboratory, he objected him in straightforward manner but finally forgave him. Most of his associates were moved by his simplicity in behaviour towards them and they worked with inspiration to the best of their abilities. Thus two Schools in colloid chemistry and Biochemistry of venoms emerged in Calcutta in between 1940 to 1965 with Professor BN Ghosh at the central position.

His research in colloid chemistry and snake venom chemistry is simple, but elegant, highly original and useful. Noted Russian Colloid Chemist Professor Deryaguin in his review on electrokinetics discussed the contribution of Professor Ghosh with high appreciation. Pioneering workers of colloid science, in those days, Professors Henry Bull, J Th G Overbeek, DC Henry and many others had applauded the research carried out by Professor Ghosh in Colloid Science from 1950 onwards. His work on biochemistry of snake venom was also appreciated all over the world and many of his original conclusions in this area still remain essentially valid. Professor Ghosh was also conscious about his moral duty as a scientific worker. As for example, he published an original paper in 1953 on electrokinetics of glass powder which was criticised and modified by a British Scientist in 1960 in the Journal of Chemical Society. In 1978, he read this criticism for the first time when he was 77 years old. He wrote a reply to this criticism and published it in 1980 since he felt that it was his scientific responsibility to clarify the position.

In 1927, Professor BN Ghosh attended a winter school on chemistry of enzymes organised by the University of London. Many eminent organic chemists and biochemists delivered stimulating lectures in this newly developed field. Professor BN Ghosh was inspired by these lectures and he felt a strong desire to carry out research on enzymes in India if he would get some opportunity for it in the future. On his return from England, he served for sometime at Kasuli Research Centre where he became acquainted further with research in the field of biochemistry and medicinal chemistry. He also received encouragement from his close friend Professor BC Guha to carry out research in the

field of enzymes present in snake venoms and in other fields of biochemistry in the Department of Applied Chemistry of the University of Calcutta. Thus being a physical chemist by training, Professor Ghosh also did fundamental work in several fields of biochemistry.

Nearly fifty students and research associates directly or indirectly collaborated research in various branches of chemistry in association with Prof BN Ghosh in the Calcutta University in different periods. Thirty students obtained PhD degree in chemistry under his direct guidance. Notable amongst his students are Dr SS De, Prof. NK Sarkar, Dr DK Chaudhuri, Dr SR Maitra, Prof DP Burma, Dr RK Neogi, Prof SC Rakshit, Prof DK Chattoraj, Prof Pasupati Mukherjee, Prof Santibrato Ghosh, Prof KC Ray, Prof SP Moulik, Prof KK Sengupta, Dr PK De, Prof KC Sen, Dr PK Pal, Dr AK Ganguly, Dr Lalita Kundu, Dr AK Roychoudhuri and many others.

In 1939, Professor Ghosh was married to Sati Gupta, daughter of Nagendramohan and Jyotirmoyee Gupta of Calcutta. Her father also obtained PhD degree in chemistry from the University of Vienna as early as 1905 in Chemistry. Mrs Sati Gupta herself a great scholar in Bengali literature also retired as a teacher of Bengali from the Calcutta University. Mrs Ghosh always helped her husband in everyway for nearly fifty years so that scientific activities of Professor Ghosh went on smoothly at different stages of life. She was always boastful of the achievement of her husband in science. She maintained great affection for the research scholars and scientists associated with Professor BN Ghosh. They have two daughters and one son in the family. Eldest daughter Dr Ratnabali Chatterjee is acting as a lecturer in Islamic History in the University of Calcutta and her husband Sri Tirthankar Chatterjee serving as Reader in the Kalyani University, is an eminent scholar in English literature. The second daughter Dr Chandra Ghosh is married to an Irish gentleman Dr. Norman A Hindson. They are settled in London as eminent doctors in psychiatry and both of them possess medical and research degrees. Youngest son Jyotibrato completed business management course in England with specialisation in computer applications and is at present serving as an officer in the Regional Computer Centre, Calcutta. His wife Kakoli, an honours graduate in zoological science is taking care of two lovely daughters and the family at their house situated in 30, Regent Estate, Calcutta.

The approach of Professor BN Ghosh to scientific activities, his feelings to students and collaborators, his responsibilities to family members, relatives and friends were all based on simple and fundamental rules of rationality, truth, love and modesty. When he was eighty six years old, he told many of us that he was in great pain to hear the news of passing away of many of his friends, past students and relatives and so he did not wish to live longer to bear the continuance of this painful natural phenomena further.

Finally he passed away on May 26, 1988 after a short period of illness. His last original paper on electochemistry appeared in April 1988.

In his childhood days, Professor Ghosh was a spectator of the early development of chemical science and chemical industry initiated by Acharya PC Ray as a significant result of the Indian renaissance movement. He himself was the torch bearer of this movement from 1925 to late part of the last decade. During this long period, he had the opportunity to observe also the enormous rise of chemical sciences in India and abroad. Professor BN Ghosh, as an Indian sage and great devotee of science has silently left a message to the younger generation of scientists to take the challenge further for the development and growth of Indian science at a high and envious point of international level using their talents, skill, devotion and originality. As an ex-student of Professor BN Ghosh the author salutes his Guru for his greatness, modesty, simplicity and dedicated service to the Nation.

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SACHINDRA NATH DASGUPTA*

(1902 - 1990)

Elected Fellow 1958

BIRTH, PARENTAGE AND EDUCATION

SACHINDRA NATH DASGUPTA, the third son of Dwarka Nath Dasgupta and Uttama Sundari, was born at Jalpaiguri (West Bengal) on November 4, 1902. Both his parents hailed from an area, Vikrampur (now in Bangladesh), which had over the centuries acquired a legendary reputation as the home of great many distinguished men and women. His father belonged to the illustrious Das family of Telirbag (Vikrampur, Dacca), in one branch of which was born CR Das, the President of the Indian National Congress in 1922. Sachindra Nath's own grandfather, Sarat Chandra Das, an eminent educationist, rose to become, in British administered 19th Century Bengal, the first Indian Inspector of Schools. His mother Uttama Sundari was from another well known family (Laskarbari Sens) of Sonarang. Sachindra Nath was more than aware (actually proud) of his intellectual heritage. His eldest brother, PN Dasgupta was an Income Tax Officer, while his second brother BN Dasgupta was Professor and Dean, Faculty of Commerce, Lucknow University, Member Tariff Commission and Founder Vice-Chancellor, North Bengal University. His younger brother MN Dasguupta was an Agricultural Graduate of Abarystwyth Wales, England, who resigned his high position in the Ministry of Agriculture,India, to devote his life for the development of agriculture and the upliftment of the poor people of Parcha, Sahabad, Bihar upto the end of his life. He had four sisters. He himself remained a bachelor.

EDUCATION IN INDIA

His early education was in Minor School, which was followed by education in Government Zilla School at Jalpaiguri, from where he passed the Matriculation Examination in First Class in 1919.

He came to Calcutta for college education and stayed in YMCA playground branch, this he considered helped him "to mould my future". He passed his Intermediate in Science from Bangabasi College in the First Division, and BSc honours in Botany from

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Presidency College in the Second Division. He passed his MSc in 1925 in Botany (with special paper in plant physiology) from the University College of Science, standing First Class first, and was awarded the University Gold Medal. He received inspiration for quest of knowledge from Prof Paul Bruhl, a most impressive teacher.

Education Abroad

He sailed to England for higher studies and research. From 1926 to 1933 he was at the Imperial College of Science and Technology in London. After taking an advanced course, both theoretical and practical, in plant pathology, plant physiology, mycology and bacteriology, he was admitted in the middle of 1927 for research in plant pathology under Prof VH Blackman, ScD, FRS. In 1929 he was awarded the Diploma of the Imperial College and PhD of the University of London. By January 1933 he had published six papers, some of which in Prof Blackman's opinion were of great mycological interest and importance and one of which he submitted for publication in the *Proceedings of the Royal Society*, London. Overcoming the desire to join Iowa University, USA, that offered half scholarship, he continued further researches for DSc under Prof Blackman with the help of Grant-in-Aid from the High Commissioner of India for a period of three years as well as Old Boy's Scholarship of Imperial College. For compelling domestic reasons he had to return to India in 1933 while on the verge of completing his DSc thesis. He was however, permitted to submit the thesis from India. Thus, delayed, the DSc degree of London University was awarded as late as in 1946. Years later in 1979, the University of Kalyani, Kalyani, West Bengal awarded the DSc *honoris causa.*

During the course of his tours of mid-Europe during recesses he visited Netherland in 1929. There he sought interview with Hugo de Vries of mutation fame, who was living a retired life in Lunteren. He kindly received Sachindra at his residence among the relic of his garden of *Oenothera lamarckiana.* This meeting was a most satisfying experience for Sachindra. FM Went in Utrecht, who was associated with Boysen-Jensen in demonstrating (by very refined techniques) the direct relationship between auxin and tropism, showed him, with rare courtsey, the most exciting revealing film, depicting the successive stages of the experiment. Not far from Utrecht, in Doorn, he watched the rare spectacle of an old man howing a log of wood in a Villa. The man was none other than Kaiser in exile, and even the view from outside the boundary wall of the villa, was exciting. In 1932 in Berlin in front of Reichstage he saw Adolf Hitler addressing a mammoth gathering and swaying the multitude with his impassioned oratory, while nearby Hindenburg was reviewing the parading troops.

SERVICE CAREER

Lucknow University

He returned rather prematurely (*i.e.* without completing DSc) from England and joined Lucknow University as Reader in Botany in 1934. Dr Birbal Sahni, the renowned Palaeobotanist, was the Professor; the other teachers in the department were Mr HP Chowdhury, Dr SK Pande and Dr AR Rao. Sachindra noted with great satisfaction that .... "it was a pleasure to work with these amiable colleagues". Sachindra was keen to visit Universites in the USA to gain knowledge of latest developments in plant pathology, but his attempts were foiled due to the second world war in 1939.

UNESCO INTERLUDE

In 1946, Sachindra received an invitation from UNESCO. He was offered the position of Counsellor in Agricultural Sciences in the Division of Science in the United Nation's Educational, Scientific and Cultural Organisation, which had its seat in Paris. Sir Julian Huxley was the Director General and Joseph Needham (Cambridge) was the Head of the Division of Science. UNESCO was located in the Hotel Majestic, 19 Avenue Kleber, a hotel which was the headquarter of Hitler, while he was in Paris.

Sachindra joined the post at Paris in August, 1946. There his colleagues were, Wang (China), Zhukova (Russia), Malina (USA), Reid (Canada) and Purnell (Australia). He actually replaced Late Bires Chandra Guha, whose term had expired. The only other Indian to hold this high position at UNESCO at that time was Malcolm Adiseshiah, who at a later stage rose to be the Deputy Director General of UNESCO.

Sachindra noted that "the emergence of *Free* India on the 15th August, 1947, an epoch making incident was celebrated by hoisting Indian Tricolour Flag by Malik, the Indian Ambassador in France before a staid small group of Indians. The assassination of Gandhi on January 30, 1948 was mourned by whole UNESCO".

Back to Lucknow University

Prof Birbal Sahni died very suddenly on 10th April, 1949, leaving a void in the botanical world that could never be filled. On the insistence of friends at the University, particularly Acharya Narendra Deo, the then Vice-Chancellor, who made a personal request, Sachindra Nath returned to India to take charge of the department of Botany as the Professor of Botany. He joined the department in December 1949, and was elected as Dean of the Faculty of Science for a short period in 1954.

Member, Public Service Commission, West Bengal

In 1958, Sachindra was invited by the Government of West Bengal offering him membership of the Public Service Commission as a prelude to taking over as the

Vice-Chancellor of the proposed Kalyani University. He joined the post in August 1958 and served until Novvember, 1960. Sachindra noted that "...these two years were the most inactive and unproductive period of my life..."

Vice-Chancellor, Kalyani University

Sachindra joined the Kalyani University as its founder Vice-Chancellor. The university started functioning with his assuming duties on November 1, 1960. He had the full support of Dr BC Roy, the Chief Minister, whose brainchild was the Kalyani University. Sachindra has the satisfaction of planning and developing this new University as an ideal residential abode of learning. He watched it making remarkable progress and receive all round approbation. But the death of Dr BC Roy was set back. However, the progress continued as the successor Chief Ministers approved the policies and extended all the support. The Vice-Chancellorship was renewed after first term of four years. Later, with the change in the Government, however, there was obvious shift in the policies, which were not to the liking of Dr Dasgupta, and he noted that "...I had the mortification of seeing the deliberate wrecking activities, emergence of indiscipline and insubordination among the students, employees of all categories and even the teachers, with consequent all round deterioration. I believe, I have the unenviable distinction of being the first Vice-Chancellor to be *Gheraoed* by the students, once for 16 hours." Sachnidra was very sad about all this and the fact that in spite of all the efforts he could not develop the University as he liked.

Retired Life

His second term as Vice-Chancellor ended on October 31, 1968. He then retired fully and never tried and declined all offer of a job or position. He felt fully free and devoted all his time in completing some voluminous unpublished research findings. He read extensively during this period and went very regularly to leading libraries in Calcutta, Lucknow and Delhi. When he expired suddenly and peacefully, he was in the process of writing memoirs of greatmen he met during his life time, a final essay on mango necrosis, a book on non-parasitic diseases of plants in India and research papers on aquatic phycomycetes.

He delivered the first Jeerasannidhi Award Lecture of the Indian Phytopathological Society in 1982 at the age of 80. He considered this "... a tribute to my age..... the invitation came to me at an opportune moment when following a few years of inactivity, after my retirement, I have just made ready for publication the work on aquatic phycomycete.. which was awaiting revision and publication for the last 25 years".

He published a 27 page paper in 1988 (*Indian Phytopath.* **41,** 521-547) on the genus *Blastocladia*. This proved his enormous will power, scientific intentions and capacity as well as zeal to work at the age of 86 years. He typed most of the manuscripts himself

and was extremely particular even for punctuations. He actually worked on the typewriter even under failing eyesight and poor health only to fulfil the mission of his life. Two of his manuscripts have already been published after his death, in *Indian Phytopathology* volume 43, pages 218-222 and pages 564-569. Several other manuscripts are in press or at the preparation stage. It is hoped that these will also be published with the help of his students and colleagues.

In 1986 in the midst of revising one of his major papers he fell seriously ill with little hope of being able to see it through to its completion. But he recovered to resume correspondence with editor of publications and recorded that"...perhaps it was ordained that I shall vindicate our work. I see no other reason for my survival".

TEACHING AND ADMINISTRATION

Sachindra possessed an uncanny vision and perception. He could easily see beyond the mountains. This helped him not only in research planning and execution but also in administration. He seemed to know the difficulties of student/administrative/teaching staff before being told. He was, therefore, prepared in advance. He had definite views, which were difficult to change because they were value based and arrived at after long deliberation. Dr BC Roy, the then Chief Minister of Bengal was highly influenced by the merits of Sachindra Nath and requested him to establish the first agricultural university in the state.

Sachindra was, thus, the founder Vice-Chancellor of Kalyani University, a position which he held with great distinction for 8 years during which he established great traditions of scholarship, justice and initiative. He was able to inspire the young intellectuals and a large number of excellent teachers/research workers from various states joined the Kalyani University. His hard work and organisational ability paid rich dividends and today Kalyani Unviersity (along with the Bidhan Chandra Krishi Vishwa Vidyalaya, which was an off shoot of Kalyani University) is one of the most active centres of agricultural research, education and extension.

He maintained very high standards and appointments/promotions were strictly on merits (actually, in the process his own students suffered a little). The 'black day' when he was 'gheraoed' overnight by the students (for passing without examination/less percentage of marks/less attendance), he showed tremendous qualities of courageous leadership, dedication to high academic standards and inspired the teachers to sit with him during the gherao. The demands of students were not met and the academic standards were not diluted. Thus, a tradition was maintained.

Sachindra was highly impressed by the flexibility in the course system followed in the agricultural universities (USA land grant college pattern), particularly because a

student, as advised by a teacher, was in a position to take up any course according to the ability as well as needs (this was in contrast to the few combinations available in the biology group/degree courses in the Indian universities). Sachindra was in favour of broad-based course training but he questioned the need for link of Zoology to Botany (at graduate level) and Bryophytes/Pteridophytes etc to Plant Pathology/Plant Physiology at the post-graduate level. He favoured the establishment of microbiology embracing mycology, bacteriology, virology and plant pathology. He was always depressed to learn that the department of Botany laid little stress on mycology and plant pathology, virology and bacteriology were not even considered in various course contents.

It is rather unfortunate that the Kalyani University with strong faculties of Art, Science, Agriculture, etc was within a decade, bifurcated into two universities, one the Kalyani University and second a Bidhan Chandra Krishi Vishwa Vidyalaya, the latter was based on the original Faculty of Agriculture of the Kalyani University (actually the College of Agriculture at Haringhata first became a part of Kalyani University and then later a part of the Bidhan Chandra Krishi Vishwa Vidyalaya).

Sachindra always felt that the sum total knowledge is so great that more careful selection has to be made in the classroom. He emphasised that teaching should not be data based but inquiry-inspiration based. The teaching of plant pathology, in his words "should thus have that orientation and philosophy behind it as would inspire students to learn to gain further insight into the subject and extend its frontiers". In his discourse on teaching of mycology and plant pathology (1967) he emphasised the interdisciplinary approach "to serve the continuing needs of plant health, the science of plant pathology not only has to borrow more and more ideas through interdisciplinary contacts but in order to move forward, the knowledge must be imparted to the rising generations of students and scholars. It is this aspect of science of plant pathology that needs closest attention and the universities have a special role to play."

Sachindra believed that "progress in biological branches of science when plotted against time is not represented by a straight and continous line. The history of science produces ample evidence of the fact that there are sudden rises of the curves, followed by plateau when no major discoveries are made for some time. The peaks normally coincide with discoveries made in other branches of science which have provided the biologists with new tools of observation and analysis". He used the term 'biochemical anatomy' for the understanding of living system (the fundamental) in terms of interaction between molecules and the known structure. When the post-graduate and school course contents are prepared the syllabus is suitable to the needs of the time; Sachindra stressed the need for a continuous revision of the syllabi so that the school course contents are 10-15 years ahead of time, and the post-graduate syllabus represents the recent advances with some futuristic approaches. The students/scholars must be exposed to the 'possibilities' because it is the potentials that are most inspiring. Overall, the courses must be flexible so that the bright student can have the choice to pursue fundamental biology. The teaching mechanism/machinery should also be overhauled from time to time

to produce personnels according to the needs of the country. Sachindra concluded that "above all it must be realised that in ultimate analysis it is the man that matters and we need teacher who must be competent, imaginative, inspiring, devoted and productive scientists".

The first final batch MSc students of Prof Dasgupta were, late GS Verma, TS Sadasivan, Anna T Zachariah and Vayusutha. A list of his students who completed their PhD is also given below along with their title of thesis.

GS Verma (*Studies in Plant Diseases)*, S Sinha (*On the Diseases of Mango Fruit and Some Related Problems together with a Study of Certain Members of the Choanephorales*), RS Bhatt (*Studies in the Ustilaginales*), SC Agarwala (*Chemical Studies in the Physiology of Mangoes*), Z Maleki (*Studies in the Fungi of Iran and India*), Rachel John (*Studies in Aquatic Fungi)*, SK Shome (*Studies in Medical Mycology*), DD Awashi (*Studies in Lichens from India and Nepal)*, JN Rai (*Studies in the Diseases of Fruit and Crop Plants*), C Sen (*Studies in Mango Necrosis and Certain Fungal Enzymes*), BB Sharma (*Studies in the Diseases of some Economic Plants*), OP Srivastava (*Studies on some Fungal Diseases of Plants and Man*), and JP Verma (*Fungal Enzymes and Their Activities*).

Research Contributions

General

Sachindra was rather critical of the gene-for-gene hypothesis. He believed that "several physiological factors and cell conditions determine the susceptibility of host tissue". Turgidity status and ability of cells to plasmolyse are importent. The recongnition of the fact that the onset of killing by fungal and bacterial parasite is determined by the failure of cells to plasmolyse leads to the question of interference with permeability regulation in the forefront. It has been known that permeation of hyphal membrane by amino acids/nucleotides is not unidirectional. But the selective leakage of amino acids (from fungal hyphae) emphasises the potential for substrate modification not only by removal of nutrients, but also by the addition of complex nutritive material by the developing mycelium. Sachindra concluded " conceivably the enzymic activities (of nucleic acid metabolism) of a fungal parasite might accelerate the turnover of host cell nucleotide, and at the same time, yield preformed purines and possibly energy to the fungal invader". He went on further to comment that "one would expect that a proteolytic or a lipolytic enzyme, or even a polysaccharide attacking enzyme, would be capable of destroying the permeability regularising mechanism of the protoplast. In addition, macerating enzymes may be directly responsible for the death of plant cells by altering the semi-permeability of their vital membranes. The acceleration of rate of destruction of plant cells may be in some way intimately related to the macerating enzyme." Sachindra felt (1967) that "...most workers... employed crude enzyme..... pectic or other enzymes involved in

pathogenesis have not yet been crystallised..... the final phase of molecular pathology will start with the crystallisation of these enzymes." He also concluded (1967) that "in order to understand the net successful activity of the pathogen, one must consider carefully the naturally occurring or pathogen induced modifiers in the host. The presence of detoxifying agents (anti-toxins) in the host must also be considered, and may have far reaching consequences in determining the resistance of host".

While in Europe Sachindra visited practically all the important laboratories and institutions in England, Scotland and Ireland; in the continent of Europe, France, Germany, Italy, Austria, Holland, Switzerland, Sweden, Norway, etc with a view to study the latest teachniques of mycological and plant pathological research and to meet and discuss pathological problems with prominent/eminent men of science.

Sachindra worked on the storage disorders of apples for the Food Investigation Board of Great Britain. He also worked at the Low Temperature Research Station, Cambridge on the problem of storage of apples. The Department of Agriculture, United Provinces, India had entrusted to him (for a period of two years) a scheme on the problem of utilisation of usar (alkali) soils of India. He is one of the few mycologists who have contributed to Medical Mycology and his review in the *Mycopathologia et Mycologia Applicata* (in 1960) still serves as the most important document for planning research projects in medical mycology.

Sachindra's dynamism and flare for critical research are well exhibited in the diverse aspects on which he published and guided research. He was responsible for laying a firm foundation to researches on host-pathogen interaction, leather mycology, paper pulp mycology, predacious fungi, aquatic fungi, deficiency diseases, air pollution, lichenology, virology, medical mycology and reclamation of usar soils. He, thus, established one of the finest schools of Mycology and Plant Pathology at the Botany Department of the Lucknow University, which attracted bright students not only from various parts of India but also from other countries as well. Space does not permit even to comment on all the important contributions made by this celebrated plant pathologist/botanist. I shall, however, mention below some of the outstanding researches in a few areas.

Saltation in Fungi

Phytopatholgy was at its infancy when Sachindra joined the Imperial College of Science and Technology, London University in 1927 for advanced researches in Mycology and Plant Pathology. The immediate problem was saltation (mutation) in several disease producing fungi (pathogens) of apple fruits namely *Cytosporina, Phomopsis* and *Diaporthe.*

Sachindra made wide ranging contribution particularly in those involving commonly observed sectorial saltation, in which the saltants varied in their points of origin, in their shape, size and other morphological characters as well as in their physiological behaviour. Besides sectorial saltation, Sachindra, came across several little known phenomena of outstanding interest; these are listed below :

(i) *Latent (maske) Saltation* : these express their identity only when separately subcultured; these continue to breed true in successive generations.

(ii) *Eversaltating strain* : in which the parent form repeats the phenomenon in every cultural generation as orthogenetic saltation.

(iii) *Cyclic saltation*, in which the saltant at some later generation reverts to the parental form.

(iv) *Conversion* of parental strain in which a strain of *Diaporthe* while retaining its parental character in the hyphae of the advancing region, undergoes conversion into a saltant strain in the older region of the mycelium.

(v) *Faster growth rate* of the saltant hyphae than that of the parental hyphae which may be correlated with greater pathogenic activity.

(vi) *Inhibition* of the parental hyphae caused by the saltant hyphae.

(vii) *Complementary Strain* : A phenomenon of profound interest is the saltation into complementary strains in *Cytosporina*. Such saltants, which are separately infertile when grown in nutritive medium, may form pycnidia along their line of junction, or form scattered pycnidia when the hyphae of the two grow intermingled with each other. This is a form of asexual heterothallism.

(viii) *Origin of Virulent strain* : This is yet another phenomenon of profound interest, particularly from the point of view of plant diseases because here the saltants possess different degree of pathogenicity. Some of the saltants were more virulent than the parent strain, demonstrating that the origin of more virulent strains from weaker strain (parent) may not be so uncommon in nature. This phenomenon poses problems in control of plant diseases.

Prof Blackman remarked on the abilities of Sachindra that "he has made most valuable contribution to mycological knowledge, especially in regard to the saltation of fungi. He has shown that a given species of *Cytosporina* may produce saltants which fall into the genus *Phomopsis* and that such saltants may saltate back into *Cytosporina*. He has studied the infecting power of the saltants of *Cytosporina ludibunda* and has shown that some of them are much more actively pathogenic than others, some of them being even more vigorous that the parent strain". Prof Blackman further commented that "More recently Dr Dasgupta has made a detailed study of two strains of *Diaporthe perniciosa* which show most remarkable releationship. One of them is *ever-sporting*, a type hitherto unknown in fungi. This strain on reaching a certain age in culture changes into a second form; this second form, however, when placed in contact with the first form is converted back to the first form, and the rate of spread of the *conversion* through the mycelium of the second form has been followed. The results obtained are of the greatest mycological interest and importance." Prof Blackman finally concluded that "Dr Dasgupta is thus a man of very high research ability".

Sachindra's monograph on *Saltation in Fungi* (1936) presents a review of the saltation phenomenon from various standpoints, discussing the types of saltation, induction of saltation by different chemicals and physical agents, morphological and physiological differences between the parent and the saltants, variation in the pathogencity of the saltants, and comparison of saltation in fungi with the phenomenon of bud variation and chimaeras in higher plants.

Mango-necrosis and Air Pollution

The detailed investigations on mango-necrosis-'a boron deficiency disease' formed the presidential address of the section of biological sciences, National Academy of Sciences, Allahabad (1959). The studies covered a period of 20 years. Mango necrosis (also known as black-tip of mango) invariably occurred in orchards situated near operating brick-kilns and was characterised by the necrosis of the tip involving about one third or half of the fruit. The important varieties (e.g. Dasheri and Safada of UP, and Langra of Bihar) were most susceptible. Fungal or bacterial etiology of the disease was eliminated and experimental reproduction of disease was attempted by air pollution by exposing healthy mango fruits to coal fumes (actually miniature brick-kilns/ovens were installed in orchards, using various kinds of fuels). His group of workers could reproduce necrosis, but the distribution of diseased fruits was rather irregular. Further, the symptoms produced by SO_2 in no way resembled the actual necrotic symptoms of the mango fruits. Another brick-kiln fume constituent, ethylene, was also not able to produce the natural symptoms either alone or in combination with SO_2. Careful work showed that at low dose the ethylene caused ripening, but at high dose it caused browning. Many other suspected compounds like carbon monoxide, fluorine, etc were also ruled out as the inducer of disease through careful experimentation. It must be mentioned that although these were rather negative results as far as mango necrosis was concerned, yet these results were laying sound foundation to the various aspects of effect of air pollution on vegetation. Some time was lost at this stage to prove that viruses were not involved either. It was then assumed that mango necrosis was a physiogenic disease caused by the disturbance of the metabolic activity of the healthy mango fruits in an early stage of development leading to deficiency due to the interaction of the brick-kiln fumes with cell metabolites.

The methodology was, therefore, altered to suit the study of deficiency diseases. It was then discovered that administration of boron as spray on trees appeared to check the advance of mango necrosis. The significant accumulation of glucose, sucrose, fructose and total sugars as also of nitrogen in the diseased portion of fruits of Dasheri and Safeda also pointed to the same conclusion (*i.e.* boron deficiency), which was further confirmed by the study of the chemical physiology of healthy mango, healthy/diseased (necrotic) portions of diseased fruits, particularly with regards to the changes in total nitrogen, total acids, carbohydrates, etc. It was finally conclusively proved that *boron* when sprayed adequately at appropriate time prevented the incidence of necrosis. It was also accepted that *the disease once present, however, is checked but not cured by the application of borax.* It was suggested that in mango necrosis, boron deficiency was not

caused by the fixation of boron in the soil but by the disturbance in boron metabolism due to the interaction of some cell metabolite of mango fruits with the constituents of brick-kiln fumes producing a substance at some stage, this substance (the causal factor) has been obtained in crystalline form. This causal factor (a constituent of gases of brick-kiln fumes) is soluble in ether (the ether soluble fraction of fumes) and chloroform. It crystallises in hexagonal form with a melting point of 110.5^{0}C; when injected in mango fruits it caused necrosis in 50 per cent of fruits. Because spray of boron prevented the disease it was concluded that the disease producing fraction produced by the absorption of the fumes, translocated into mango fruits, and induced boron deficiency on one hand, while on the other hand, it caused histopathological changes, forming deposits in the vessels and choking/impeding or altogether stopping the translocation of metabolic products that help to develop necrosis from the tip end. The studies demonstrated the multidisciplinary approach to solve a problem in the national interest in an economic way. In the end, however, Sachindra, was not satisfied and wished to pursue the studies further *to unravel the precise steps by which the disturbance in boron deficiency may be brought about and to get a clear picture of the enzymatic systems which are involved in the process.* The investigations of boron deficiency disease of mango ushered in a new era of plant pathology in India focussing attention on deficiency diseases, air pollution and non-parasitic diseases. His presidential address on air pollution to the Botany Section of the Indian Science Congress (1957) reviewed, for the first time from India, the data available from the industrial countries (Germany and Britain in particular). He drew attention, with telling figures, to the human health hazards from air pollution and profound deleterious effect on agriculture (destruction of growing crops, diminished yields, damaged vegetables, etc) besides posing serious national environmental problems.

Sachindra made a serious plea (in 1957) for the scientific studies by the respective disciplines (physics, chemistry, biology) of the polluted atmosphere, evaluation of weather effect on air pollution, epidemiology, human/animal health hazards and damage to vegetation/agriculture. India was then at the threshold of industrial revolution under successive five year plans, and the country was going to face extensive damage through air pollution because new factories were being launched, refineries were started and other industrial plants were being erected. He urged legislative action to control, at the source, the pollutants produced as the bye products of industrial processes and fumes. These could be done, as he concluded *without waiting for indigenous research, by borrowing the design and technology from abroad.* However, all these remained unheeded until in the mid-seventies, the Los Angeles environmentalists paraded the streets with gas masks on, to bring home, the impending dangers to human survival.

Aquatic Phycomycetes

The study of the aquatic phycomycetes in the Lucknow University, which had suffered initial failures, received tremendous impetus from the detection of chytridial parasites in many specifically unidentified algal hosts like *Spirogyra, Oedogonium, Closterium*, and to a less extent *Cladophora, Zygnema, Ulothrix*; and among the animalcules

in rotifers, their adults and eggs as well as the appearance of profuse number of members of *Blastocladia* of the order blastocladiales and other orders from appropriate baits.

He (in collaboration with Rachel John) described over 70 species of aquatic phycomycetes; several other species are awaiting identification/publication (the completed manuscripts are at various stages of publication). The identified species have yielded, at least, five orders, chytridiales, blastocladiales, monoblepharidales, lagenidiales and entomophthorales. Three new genera have been proposed to accomodate four new species which could not be placed in any other known genus. *Monophagus* gen. nov. belongs to the suborder polyphagoideae of chytridiales, and is closely related to *Polyphagus*. *Indocytium* gen. nov., belonging to lagenidiaceae, is related and associated with *Myzocytium megastomum*. *Sparrowmyces* gen. nov. is parasitic in *Ulothrix* species and possesses epibiotic sporangium, endobiotic apophysis and extracellular free floating copiously branched rhizoids arising from apophysis penetrating through the lower cell wall of the host *Ulothrix*; this type is wholly unknown in any other aquatic chytrid. The validity of these new genera has yet to be established.

A large number of manuscripts are ready for publication; these deal with the revision of the following genera, *Olpidium, Rozella, Phlyctidium, Rhizophydium, Blyttiomyces, Entophlyctis* and *Rhizidia* (inoperculate chytridiales), *Chytridium, Macrochytridium* and a proposed new genus *Sparromyces* (operculate chytridiales); *Catenaria, Allomyces* and *Blastocladia* (blastocladiales); *Gonapodya* (monoblepharidales); *Olpidiopsis, Myzocytium* and *Lagenidium* (lagenidiales), *Ancylistes* (entomophthorales). Such a huge collection from a single laboratory within a short span of 5 years is indeed phenomenal, and is surpassed only by Sparrow, Karling and perhaps Scherffel.

A comprehensive account of the status of aquatic phycomycetes was presented in 1982 in his Jeerasannidhi Lecture (*Indian Phytopath.* 35: 193-216) where he remarked that "Discovering new and less known genera is both exciting as well as encouraging and must be pursued with all earnestness. Besides, these form the foundation of phylogenetic work, providing in many cases link species. But equally, if not more demanding, is the thorough study of the different phases of the life cycle of marginally placed newly found species with special emphasis on the characters which are known to be of importance from the classificatory point of view".

He went on further to advise that *our maturity demands that not resting content with survey alone, the taxonomists take up the critical study of the individuals of those areas which are unsettled and speculative, besides the monographic studies of such groups which are well represented in India. The literature abounds in cases where the critical developmental stages of species are unknown or imperfectly known, where the limits of genera, families are not well delineated, where opinion differs as to their taxonomic status. Contributions in these areas may lead to the emergence of new facts, conduce new concepts, invalidate some which are now extant, solve many problems confronting the present day mycologists, and throw up other problems to be solved in their turn, gradually moving towards possible*

phylogenetic classification. Finally he concluded that there remains a vast field to explore in India, elsewhere as well, only a fringe has been touched.

HOBBIES

Sports

Sachindra Nath was a man of varied interest. He possessed a good physique and maintained a sound health throughout his life. He was highly proficient in most of the outdoor games, but excelled in tennis. He disliked indoor sports like chess or cards. He was a keen footballer. He used to say that, at school after a game of football in the evening, when he got back home (tired and exhausted) his mother would rebuke him daily for being so unmindful of his studies. He carried this interest in outdoor sports to Calcutta where in the YMCA, he participated fully in all games.

In London he earned a University Blue in tennis. In Lucknow he became the presidennt of the University Lawn Tennis Club. He was so fond of tennis that he could be often seen playing with great vigour and swiftness (so characteristic of him) in the staff courts of Lucknow University. With age, he later switched to badminton.

Music/Painting/Languages

He would often refer to his lack of ear for music very apologetically, because Lucknow during his time, was the acknowledged centre of Hindustani music. But this lack of interest in music was true only of the vocal side. In London, he did a full course at the Putney School of Art, and his surviving pencil portrait sketches are perfect. He was not a great social mixer but he developed abiding friendship with individuals among whom were the sculptor Hiranmoy Roy Chaudhuri (who also did a marble bust of Sachindra) and the painter Lalit Mohan Sen, both of the Lucknow School of Art.

Foreign languages fascinated him and he dabbled in many but was particularly fond of German poetry. A framed German hymn always stood besides his writing desk. It said (translated) "When you have the sun in your heart then come what may your darkest day will be full of light. Have a word for others in sorrow and in pain and that will make you feel glad too". He had a profound admiration for Germany and German Culture. For Lucknow, he continued to have an affection which made him visit it twice every year until his last days. Like many of his generation, he had a good grounding in Sanskrit language and literature. After retirement, he wrote half a dozen short stories in Bengali, which, however, never got published, more as social romances than a depiction of society. His reading habit curiously included a heavy doze of thrills.

Trekking/Mountaineering

He was very fond of travels in the Himalayas. The summer vacations in the Lucknow University were often spent by him in travelling through different parts of Sikkim, just with one porter. He maintained details of his day to day journey in the diary, mentioned

the type of route, miles traversed, people with whom he came in contact, the vegetation and the food he was able to get. He relished the simple food items like 'dal' and 'roti' or dal and rice only. His nature to adjust and be happy with diverse inconveniences of shelter, food, etc. was marvellous. It is fortunate that I have a write-up in Sachindra's own typed manuscript on interest in mountaineering. I reproduce that to demonstrate his tremendous interest in trekking as well as his adventurous nature.

"Trekking has been my hobby and pleaasure. Adventure is in my blood. Leaving aside juvenile excursions to the forests of Dooars, ruins and temples, the first initiation in adventure was in 1919, at the age of 16, immediately after matriculation, along with two friends of like mentality, we trekked from Siliguri to Kurseong (5000 ft), a distance of 25 miles through the dense Sal forest and mountain stream (now practically non-existent). Starting at the very small hours of the dawn with lighted torch to scare away wild elephants and animals following uphill tracks we reached Kurseong near about midday. Resting the night we walked along the cart road (taking short cuts wherever possible) to Darjeeling (8500 ft), another 25 miles. Much later in England I was initiated in mountaineering in Snowdon (Wales) by Sir John Farmer. Further mountaineering and trekking were done in Germany (Black Forest) and Switzerland, notably Junge-Frau, with the help of professional guide".

"Futher opportunities came in the way at Lucknow University. There my most valued friend and colleague, Dr SK Pande, of Bryology fame, a trekking enthusiast, no doubt inspired by his teacher Prof. Kashyap, became my constant companion. With our combined enthusiasm, between 1935-1945 we took a series of excursions systematically from Kashmir to Cape Comorin and Ceylone (now Sri Lanka), to areas important from botanical, geological and religious point of view. Among these trekkings the most rewarding were the trekkings in the Western Himalayas. Starting with Pindari Glaciers (13,500 ft) we visited many other Himalayan resorts like Milam Pass (14,500 ft), Kedarnath, Badrinath, Yamnotri, Gomukh etc".

Solo Mountaineering in Sikkim

"My solo venture in trekking/mountaineering was the land of Sikkim. It was my favourite haunt for three successive seasons from 1939, terminating with the bombing of Calcutta by the Japanese in 1942. The first trek was the round trip from Gangtok to the South-East region of Sikkim. From Gangtok I trekked to Karponang (Possum), along a narrow mountain track, skirting an awesome abyss, the both faces of which were covered by Rhododendron plants, and in the season I visited, it was an unbroken view of a riot of gorgeous red flowers as far as eyes could travel. From Karponang I trekked to Changu Lake (12,500 ft) which is about a mile long glorious expanse of water, when viewed from a cabin at the western end. I then proceeded on to Nathu La (14,000 ft), then to Jelep La (13,500 ft), over which passes the Kalimpong-Lahsa trade route, the gateway to Tibet; from there to Kapup, Sedonchen (6,500 ft), to Rhonak and up towards Pakhyong, and finally back to Gangtok".

"The next trip, with a Lopcha guide, was to Donkhya La (18,100 ft). From Gangtok, following the same route as for Sebu La (*infra*) we came to Chungthang, crossed over to Lachung Valley, to Lachung, then to Yumtang, to Mome Samdang, and from there to Donkhya La. I retraced my foot steps, instead of crossing over the fairly easy pass. There at the foot of the hill I had the temerity to take bath in the ice-filled mountain stream at a height of over 17,500 ft. Almost frozen blue and paralysed, I was warmed and revived by the Yak dung fire prepared and kept ready by the guide. I returned back to Gangtok by the same route".

"The acme of my Sikkim mountaineering was when I crossed Sabu La (17,500 ft) from Lachen Valley to Lachung Valley. I started from Gangtok with the same Lepcha guide, with Ice Axe and a few other accessories, taken on loan from the Himalayan Club, Calcutta. Down we went meeting the river Tista at Dikchu, our first *Parao* (stage). Our wooden shelter, where we passed our night, was practically over the awesome, deafening roaring torrents hurtling down its course. Next morning we trekked up to Mangen and continued upto Singhik (4,600 ft). Rested the night. In the morning Singhik presented a most magnificient, exalting, panoramic view of the Kanchanjangha range, that appeared to dominate Sikkim. Face to face with Kanchanjangha, adjudged as the most beautiful and symmetrical peak of the world, the eastern face of which shimmered and glittered as a sheet of gold in the morning sun, true to its name, a sight that fascinated me even as a child, while watching the peak from the iron bridge that spanned the Karala river (Jalpaiguri) on my way to morning school. The glory of the vast, massive, pinnacle of Kanchanjangha range left me spell bound. We proceeded onward to Toong and from there to Chungthang (5,350 ft)".

"Chungthang is in the confluence of two rivers, Lachen Chu and Lachung Chu, mingling their waters to form Tista. We passed on along Lachen Valley to Lachen (8,800 ft, then to Thangu (12,8000 ft). From there, the path lay over Sebu La to Lachung Valley. Starting early, trekking, which involved occasional cutting steps with ice axe, alternatingly the guide and myself, again at some stages crossing dried-up river beds, skirting, avoiding, treacherous possible quick sand, and fallen trees and boulders. We hurried on, as best as we could, afraid to be engulfed by sudden onset of darkness, in that mountainous forest region, which would spell disaster. It was just in fading evening light that we reached Mome Samdong (15,000 ft) in Lachung Valley. There we took shelter in the Himalyan hut. We had traversed, in one day, what normally, enjoyable, should be done in two stages with proper equipment. There, for the first time, I experienced mountain sickness. Food cooked by solicitous guide remained untouched. Nausea, high fever and fearful dreams gave a disturbed night. Gradually all these passed off and I slept soundly into the morning. Next day was a day of repose. The day following weary limbs rested, revived and refreshed, we embarked on return journey, following the treck along the Lachung river, arriving at Yumtang, Lachung, back to Chungthang, finally to Gangtok, following the same route as on our onward journey to Sebu La. At Gangtok, after a few

day's rest I bade farewell to my amiable, companion and guide. Thus ended my Sikkim odyssey".

Fellowships, Awards, Honours and Distinctions

Sachindra Nath was honoured by various societies and was elected as the President, Indian Botanical Society (1947), President of the Indian Phytopathological Society (1954) and President, Botany Section of the Indian Science Congress Association (1957). He was Honorary Fellow of the Indian Phytopathological Society, Honrary Fellow of the Indian Botanical Society, and Foundation Fellow of Indian Academy of Sciences, Bangalore. He was also a Fellow of the National Academy of Sciences, Allahabad, Emeritus Member of the American Phytopathological Society, Member Societe Botanique de France, Member Editorial Board of Mycopathologia et Mycologia Applicata and Member, Indian delegation at FAO conference on Freedom from Hunger at Washington (1963).

The famous Italian Naturalist O Campese dedicated his monumental work on Culture Tropicali, Volume-VI to Prof SN Dasgupta as a token of esteem and appreciation. A special volume entitled "*Current trends in Plant Pathology*" edited by SP Raychaudhuri and Jeevan P Verma, was dedicated to him on the occasion of his 70th birthday in 1974 during the Indian Science Session held at Nagpur. He was awarded DSc (*Honoris causa*) in 1979, as the founder father by the University of Kalyani, West Bangal. The citation described him as *an eminent scientist and a distinguished academician who combines in his gentle personality the noblest traditions of learning, the challenging spirit of the scientific explorer and the inspiring vision of the creative genius.*

He was also Member, Governing Body, Birbal Sahni Palaeobotanical Institute, Lucknow, Member, Advisory Council, National Botanical Research Insitute, Lucknow; and held important positions in various societies/academies.

The Karmayogi

Sachindra Nath had a deep faith in God, but an equally great contempt for religious rituals. He believed in the goodness of his actions. In 1986 while revising one of his major papers for publication he fell seriously ill with little hope of survival. When he recovered and completed the manuscript he wrote to the editor *perhaps it was ordained that I shall vindicate our work. I see no other reason for my survival.* Sachindra was research minded and felt *guilty for shifting to administration*, but even this he accepted as the act of God when he said that ... *but it is fate.*

When he started working on the publications of old manuscripts in the seventies, he faced acute problem in obtaining the recent number of jounrals. As the IARI library is very good, he wrote to me very often for Xerox, books, photos, etc. He took help from very few, and only willing workers. He wrote to me ultimately on 1-9-89 that *excepting you and one or two others there is none to help. They think perhaps it is futile to pretend research at this old age.* His health was particularly poor during the last 5-6 years, but this never stopped him from working. He worte on 1-1-88 that *now that I am better I am going to trouble you again.* He used to write even upto ten items to be done in a single letter. But he was aware of others problems and admitted that *I have worried you with many trivial matters in the midst of your multifarious more important activities, academic and otherwise.* When I was the President of the Section of Agricultural Sciences (Indian Science Congress) and preparing my presidential address he wrote *you are surely concentrating on your presidential address... Let not these paltry matters divert your attention.* Once he wrote *I was feeling too diffident to continue to trouble you.* After the address he had the kindness to congratulate me and say *this is just to congratulate you on your penetrating, thought provoking address, rational in its approach and bearing a stamp of erudition. God bless.* He not only cared but also encouraged and inspired his students with similar remarks.

Once when he was very sick he wrote on 4-1-90 that *when your last letter arrived I was fighting for my life in a nursing home. Unfortunately I won. A further step, I would have merged with eternity. What a relief it would have been.* He, however, was true Karmayogi and advised that *Man can only try-the success is in the hands of God. Let not spurious ambitions deviate you from the main purpose of life.*

On April 14, 1990 he wrote *I write as I feel coming to the end of the journey. I hesitate not to express myself as I feel. My health is failing. But I keep on working while I may. I shall be happy if the end comes suddenly without notice.* True to his desires his end was sudden and peaceful on the night of 11/12 September, 1990.

His life was so honest, straight forward, truthful, sincere and disciplined that one would like to imbibe something from it. He was always full of new ideas and generous in sharing them with his colleagues and students, often allowing them to take much of the credit. He was held in awe for his dynamic personality and simultaneously respected for his humanitarian views. He was Godfather to three children's institutions; this became known only after his death. He donated his large and magnificient personal library to the University of Kalyani. He lived in a shell, and only the few who could penetrate this hard shell became aware of his softness and love for the weak as well as respect for the outstanding. He liked to help the deserving ones, but without being known as the helper, and the help was always in plenty, with modesty and with sympathy. His kindness and warmth of personality made him many friends, more admirers. Sachindra was a bachelor. But he has left behind a large family of mourners, which include his near relatives, students, colleagues and admirers.

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B. Sanjiva Rao

BASRUR SANJIVA RAO

(1895 - 1975)

(Elected Fellow 1944)

BASRUR SANJIVA RAO was born on 23rd February 1895 in Coondapur located in the Dakshina Kannada District of Karnataka as the fourth son of B Subba Rao, a pleader who practised at the local Bar. He received his education up to Matric (equivalent to the present 11th standard) in Coondapur. In those days, the teachers took great interest in the studies and welfare of their students. Buntwal Raghunathaiah, who was the Head of the school coached the students personally and accompanied them to Mangalore to write the Matriculation Examination, as there was no centre at Coondapur. Sanjiva Rao passed the Matriculation examination in 1911 with a 1st class. He proceeded to Bangalore and joined the BA Science Course at Central College. In those days, even the science course was designated as a BA course. Sanjiva Rao was a highly studious and motivated student and took a first class in the BA examination. He was a scholarship holder throughout his studentship in Central College. After taking his BA degree, Sanjiva Rao applied for a seat in the Indian Institute of Science, Bangalore and got a seat in the then General and Orgainc Chemistry Department (now this department has been split into two). However, his Professor Dr Usher of the Department of Chemistry persuaded him to take up demonstratorship in Central College; and he was appointed as a demonstrator on a pay of Rs. 75/- pm in 1915. He was made a senior demonstrator a couple of years later, and subsequently an Asst Professor. Sanjiva Rao's scholastic attainments and dedication to duty enabled him to secure the Damodardas scholarship awarded by the Government of Mysore. With this scholarship he proceeded for higher studies in England to study at the Imperial College, London from where he obtained his PhD degree in 1924 and returned to Central College. He succeeded Professor FL Usher in 1926 as Professor of Physical Chemistry and later when Prof MG Srinivas Rao passed away in 1928, he was made the Head of the Department of Chemistry in Central College. He was appointed as Principal of the college in 1946 and served the institution in this capacity for a year. During this period several eminent persons were working in different science departments of Central College and the College was well known for its research activities. Sanjiva Rao contributed to a great measure towards this recognition of Central College as an institution known for research. Professor Sanjiva Roa trained a large number of students in research methodology and several of them obtained their doctorate degrees under his guidance. Quite a few of his former students have risen to great heights in their research accomplishments and have been able to occupy important positions in the scientific institutions of the country.

Dr Sanjiva Rao's research activities have been very varied. He has carried o extensive work on natural products especially of essential oils. He has also considerab work to his credit in the area of adsorption. His work on the Oxides of Sulphur monoxi and other sulphur compounds is quite unique and established him as a worker of repu and earned for him the DSc degree of London University. In later years Professor R was much intersted in the area of soil chemistry and has made significant contributio in this area as well.

A list of his important research publications is enclosed at the end. Some of h junior research collaborators are listed below :

1. Prof KSG Doss, 2. Prof MRA Rao, 3. Prof K Subbarao 4. Prof RS Subramany 5. Prof AR Vasudeva Murthy, 6. Dr GN Subba Rao, 7. Prof G Narayan 8. Shri T Krishnap 9. Dr Sharada Gulvadi 10. Shri HM Channabasappa 11. Dr NG Chokanna 12. Shri M Wazid 13. Prof SN Venkatachala 14. Shri KS Subramanian

Dr Sanjiva Rao was also responsible for the re-organisation of the teachi programmes in Chemistry in Central College leading to BSc, BSc (Hons) and M degrees of the Mysore University. The science departments at Central College constitut the university departments of the Mysore University during these years. A large numb of undergraduate and post-graduate students have received instruction from Prof Sanji Rao as students of the above courses and have risen to occupy important positions administrators in civil services and as technocrats in industry.

After retiring from Mysore University in 1947, Prof Sanjiva Rao joined t department of Inorganic and Mineral Chemistry of Indian Institute of Science to be t HEH Nizam Professor of Inorganic and Mineral Chemistry. Dr Sanjiva Rao later shift to the University of Gauhati in Assam to organise the Department of Chemistry an retired from service of the Gauhati University in 1961. Even after retirement, Profess Sanjiva Rao continued to take interest in both fundamental and applied research proble and worked at the Indian Institute of Science under the retired scientists scheme sponsore by the UGC. Even during later years he kept abreast of the developments in his are of interest by regular visits to the Library at Indian Institute of Science.

Dr Sanjiva Rao was actively associated with several scientific and educatio organisations and institutions of the country. He was an active member of the Society Biological Chemists and also its president in 1955. He was General Secretary and Preside of the Chemistry Section of Indian Science Congress Association held in 1947. He w fellow and treasurer of Indian Academy of Sciences, Fellow of the National Institute Sciences, President of South Indian Science Association and Scientific Film Society India. He took keen interest in educational programmes at all levels starting from prima school up to university level.

Professor Sanjiva Rao had three sons and two daughters. All the sons are happi settled abroad. He was an active Scout and also Superintendent of St John's Ambulanc Brigade for some time. His hobbies were gardening and cookery.

The Scientific community suffered a serious loss in the demise of Dr B Sanjiva Rao who passed away on March 3rd, 1975 when he was just 80 years old.

Some of his former students have raised some money and instituted the following in the Bangalore University (Central College is now a part of Bangalore University) to perpetuate the memory of Prof Sanjiva Rao.

1. A gold medal to be awarded annually at the Convocation to a student who secures the highest marks in Inorganic Chemistry at the Master's degree examination of the Bangalore University.

2. Two or three prizes to be awarded to the best speakers at an annual lecture contest conducted by the Chemical Society of the Bangalore University.

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ROBERT BERESFORD SEYMOUR SEWELL*

(1880 - 1964)

Elected Fellow 1936

LIEUTENANT-COLONEL ROBERT BERESFORD SEYMOUR SEWEEL, CIE, FRS, died in Cambridge on 11 February 1964, at the age of 83. He was almost the last of a great generation of British zoologists who, brought up wholly in the grand nineteenth century tradition of evolutionary biology, saw and had to adapt themselves to the great change of outlook which began to overtake zoologists in the first decades of this century and which still continues.

He was born in Leamington on 5 March 1880, the second son of the Reverend Arthur Sewell and of Mary Lee Waring, whose father Henry Franks Waring was practising solicitor in Lyme Regis. Though born in Warwickshire, Seymour Sewell came of one of those Wessex Families which have maintained and still maintain a steady distincition through the generations. Longevity also ran in the family. His great-great-grandfather William was made Fellow of Queen's College, Oxford, in 1753 and took the College living of Headly, Hants, in 1765. He lived to the age of 80. His son William (1804-1897) was Fellow of Exeter College and held the degree of DD. He was a joint founder of St Columba's College near Dublin, and founder of St Peter's College, Radley. The second son James Edwards (1810-1903) was Fellow of New College, Oxford, and in 1860 became Warden and held that office till his death. Their sister Elizabeth Missing Sewell (1815-1907) was a distinguished authoress and pioneer of education for girls. Seymour Sewell's father was at Radley and New College, where he was a choral scholar. He became Chaplain to the Order of St John of Jerusalem, and died at the age of 106.

During Seymour Sewell's childhood the family moved to Weymouth, and he grew up there in the preparatory school, Cleveland House, which his father ran in connexion with Weymouth College. It was a family with pride of tradition, in comfortable circumstances, very adequate though not outstanding in its culture, conservative and somewhat conventional in general outlook.

Sewell himself never quite fitted the family pattern. His brothers took up classics, but though he was tried out in the Classical Sixth at Weymouth he would say that this was with an unsuccess only less than that of his subsequent failure in the Mathematical Sixth. At this point by good fortune the Science Master, a man of evident insight, asked to have him-'I believe the boy would make a scientist'-and from that point he never looked back.

* Reprinted from Biographical memoirs of Fellows of Royal Society London, Vol II, pp. 147-155.

In 1898 he obtained an Exhibition of Christ's College, Cambridge. But before going there the following October he spent six months studying zoology under Professor Weldon at University College London. That first biological initiation may perhaps have given his career its final direction. The new outlook was just beginning to colour the pure comparative anatomy of Haeckel and Huxley. The violent tripartite controversies between Weldon the biometrician, Bateson the neo-Mendelian, and the traditional evolutionary biologists are reflected in HG Wells's tale *Ann Veronica.* It was an exciting time to become a zoologist.

In October 1899 he entered Christ's College. Shipley, who in later years became Master and one of the great Vice-Chancellors, was in his most active phase as a zoologist and parasitologist. As always, he gave this young biologist very great help and encouragement.

These were days when a young biologist received a wide education of a kind hard to envisage today : Greek Testament and Paley's *Evidences of Christianity* in the Little-go, zoologyy, physiology, chemistry and human anatomy in Part I of the Tripos, and both physiology and human anatomy in Part II. Seymour Sewell distinguished himself and obtained his 'Double First' in 1903. After that he was appointed Junior Demonstrator first in Anatomy and subsequently in Physiology. In October 1905 he entered St Bartholomew's Hospital where he continued to distinguish himself and became qualified MRCS, LRCP in October 1907.

His experiences at 'Barts', very human ones, left a deep impression on him. He used to tell of the little boys who would hang on the back of the meat wagons as they pulled out a Smithfield and then always fell off at the corner, to be brought in with concussion; or of being 'out on the District', returning home in the early hours after delivering a baby in some poor home and calling in at the cabbie's shelter for 'a doorstep and a cup of thick', which is a slice of bread and margarine and a cup of cocoa.

His pride in and loyalty to his old hospital lasted all his life, and it gave him great delight when his elder daughter, Rosemary, took up nursing, trained at 'Barts' and was awarded the Gold Medal for excellence.

He had thoughts at one stage of becoming a surgeon, a profession for which it might seem he would have been fitted, at least by virtue of his absolute steadiness of nerve (he was wonderful man in a crisis of any kind) and a beautiful degree of manual dexterity and delicacy, which however, stood him in good stead in his scientific work later. In the zoological part of his life one used so often to go into his laboratory and find him seated at his microscope, either drawing in meticulous and infinitely patient detail his minute copepods, or else dissecting them into even more minute pieces by means of the finest steel sewing needles which he had honed down even further.

In 1908 he joined the Indian Medical Service, with which he was associated in various capacities for 28 years. Entry into the Indian Medical Service was suggested to him by his uncle, Robert Sewell, who was already in Government service out in India. Since the IMS was an Army service, he had as a future officer to learn to ride, and spent

six weeks at Aldershot for this purpose, a period he always spoke of with some amusement. Later, when his service took him up to the north-west of India and Kashmir he had his own pony and rode a good deal, both in the course of work and for pleasure. Seymour Sewell's first appointment was that of Medical Officer attached to the 67th and 84th Punjabi Regiments, and he became Malarial Officer to the Sialkote Brigade.

But then his ability and the early training he had received as a zoologist under Shipley and Adam Sedgwick turned him along the same path that Thomas Henry Huxley and other medical biologists had followed. In 1910 he became Surgeon-Naturalist to the Marine Survey of India, and Hon. Assistant Superintendent in the Zoological Section of the Indian Museum at Calcutta. His years as Surgeon-Naturalist on the *Investigator* may well have been among the happiest of his life. His job, as he recounted it, was to look after the health of those on board, annd pursue his own scientific interest on the side; but, as he said, no one was ever ill and apart from the occasional accident he had no medical duties, and so really began then on what was to be his major interest for the rest of his life, marine biology and oceanography. He loved the life on board; was a born sea-goer and greatly enjoyed the type of club-like masculine companionship a ship affords. It helped him when he ran his own ship, the *Mabahiss,* which the Egyptian Government lent for the John Murray Expedition which he headed, in 1933. As Surgeon-Naturalist he served on board the RIMS *Investigator* off the southern coast of Burma, and with his ever widening knowledge of zoology in general and marine biology in particular he was seconded as Professor of Biology from 1911 to 1913 at the Calcutta Medical College.

The events of 1914 abruptly cut short all his plans. On 5 August, the day after the declaration of that war, he was married at Chichester to Dorothy Dean, youngest daughter of William and Matilda Dean, but like so many at that time he had at once to depart on military duty. He served in Aden, where he became Port Health Officer. From 1916 he served first in Sinai, and then with Allenby in Palestine. His qualities made him a good soldier. He was mentioned in despatches in 1917. He had the professional soldier's distrust of Lawrence of Arabia, 'Never there when you wanted him.'

After that war Seymour Sewell returned to India as Superintendent of the Zoological Survey. Later he again became Surgeon-Naturalist to the Marine Survey until his appointment in 1925 as Director of the Zoological Survey of India. He was then also head of the Indian Museum, and living there in Calcutta. He had under him at this time a numerous and widely varied Indian staff, and it was during this period that he built up his excellent and wide-ranging connexions with Indian scientists, a relationship which was a continuous feature of his life from then on. During the whole of his retirement he maintained a wide correspondence with former colleagues and fellow-scientists in India, supported their candidacies for various honours, was visited constantly in Cambridge by Indian scientists, students or established experts, who came to him for advice, encouragement, or professional exchange of views. In 1946 the newly independent Government of India invited him to go out and advise them upon expanding zoological studies, including fishery, and he spent four months there, travelling round, meeting people and drawing up a scheme for progress in these fields. He felt personal interest and

responsibility for Indian students in England in his own field. On one occasion he wrote a furious letter to the Government officers concerned when he learned that they were proposing to require young Indian students who came to England to take a PhD and who failed to obtain the Degree, to return to India and to repay all the money they had received from the Government in grants; he told them bluntly that it was the most direct incitement of suicide he had ever come upon.

On his retirement from the Indian Medical Service in 1933 Seymour Sewell was appointed CIE. That year also marked an important event his appointment as Leader of the John Murray Expedition to the Indian Ocean. That expedition was great success. Its work embodied the first application to tropical waters of the fundamental principles laid down by the late WRG Atkins on the role of light and of minor chemical constituents in the productivity of the sea. Likewise, the discovery of the deep-water 'azoic' region in the northern part of the Indian Ocean and the geographical continuation of orographical features of Southern Asia below the surface of the ocean. There is at present a greatly renewed interest in the oceanography of the Indian Ocean. At oceanographic conferences today one is sometimes a little puzzled by the fact that some workers seem to grope towards principles which were in fact so clearly foreshadowed in that earlier expedition.

All these aspects were developed by Seymour Sewell in that expedition, but his personal interest was in the taxonomy and distribution of oceanic animals, particularly the Copepoda, on which important group he was a world authority. He was not a purely laboratory systematist, quietly dividing the species and varieties of spirit collections. As a biologist, he was never truly academic. Rather, he belonged to that same class of taxonomer-naturalists which include Alfred Wallace and Charles Darwin himself. It was the interaction between organism and environment, and the relation of the distinction between species and their distribution that fascinated him. Inevitably in later years he became more and more interested in Wegner's theory of continental drift and its consequences upon distribution, not only upon land, but of species in the sea. His final Presidental Address to the Linnean Society in 1955 set out his position very clearly.

Seymour Sewell's marine contribution to the Wegner drift theory, like that of Hamshaw Thomas's on the historical distribution of terrestrial plants, played an important part in the history of the theory. Both provided powerful inductive arguments in favour of Wegner. In both cases conviction carried by such an argument depended upon the extent to which a reader was fully seized of the variety and the quality of phenomena very familiar to such expert taxonomers. But on the geophysicists they necessarily made no impression; the arguments were brushed aside and we were told that such drift of the continents was impossible-just as in the last century Lord Kelvin had peremptorily informed geologists that the age of the earth could not possibly exceed a hundred million years. In both cases such words were subsequently eaten with apparent enjoyment, but it should not be lost upon us that the inductive arguments of Seymour Sewell and Hamshaw Thomas in fact led to conclusions which the former opponents of the drift theory now recognize as sound-or even self-evident.

During the 1930s Seymour Sewell was not only busy with the reports of the John Murray Expedition and with his current taxonomic and other researches, he began the great work of taking over the editorship of the *Fauna of India.* That he continued, finally with a co-editor, until the year before his death. His friendship with Professor Stanley Gardiner and their common interest in oceanography led him to retire to Cambridge, where he worked in the Department of Zoology. At the outbreak of the Second World War he was recalled to medical duties, his name being still in the Medical Register, though of course he had not practised for twenty years. He was comically dismayed-'I'd be a public danger!' He was released from this call-up, but all through the war was head of a first-aid post in Cambridge; he may even have been a little disappointed that they never had any casualties to deal with. He was awarded the Civil Defence Medal.

Like the late Dr Borradaile, he offered his services for teaching in the Zoological Laboratory with its attenuated staff. Though not by nature an academic teacher, his lectures, like those of Borradaile, were a success. In the early 1920s evolutionary taxonomy-what Borradaile called 'the pageant of the animal kingdom'-was still one of the most exciting things for a student of zoology. By the mid 1930s all interest by the student in such things had passed in favour of the newer rapidly developing parts of zoology. But by the 1940s, one could already see the revival of such interest among the students, so much of what we think important, or out-dated, in natural science, is in part a matter of fashion and emotion. That revival of interest in the pageant of nature seems to have come to stay-in the long run respect for natural phenomena is more secure than respect for contemporary ideas-and Seymour Sewell played his part in that revival.

In Cambridge he was a well-loved figure, though no one knew him really well. That was I think not because of a lack of social qualities. But old men lose the friends who shared their memories-friends such as Annandale of the Calcutta Museum, and Stanley Kemp of that same Museum and later of the Marine Laboratory at Plymouth, who knew Seymour Sewell well in his Indian days. Moreover with advancing years he became crippled and finally incapacitated with arthritis, and though he continued to work almost to the last he could not easily join in the over-busy life of the Department around him.

Apart from his work, his main interst in life was Freemasonry. He was initiated in 1912 in Lodge 'Concordia', No. 3102 EC Calcutta, and in 1927-1929 became its Master; in 1930 he was given the rank of District Grand Junior Deacon (Bengal). When he retired from the Indian Medical Service and settled down in Cambridge he was accepted as a joining Member by Lodge 'Alma mater', No. 1492. This Lodge was for Senior Members of the University (MA standing) or of Oxford, and he became its master in 1947-1948. During his term of office as Master he joined the other University Lodge, 'Isaac Newton', No. 859, and in 1950 he was given the rank of Provincial Grand Senior Warden in the Province of Cambridgeshire. In 1953 he became a Founder Member of a new Lodge, 'Thirkill', No. 7333, and in 1956-1957 he was elected Worshipful Master and, finally, in 1958 he was given the rank of Past Grand Deacon in the Grand Lodge of England.

He received many honours. To mention only some, he was elected FRS in 1935. He was President of the Linnean Society 1952-1955, and of the Ray Society 1950-1953,

and became Corresponding Member of the Academy of Natural Sciences of Philadelphia in 1935. His services were often called upon, as in his Secretaryship of the International Joint Commission on Oceanography (1944-1951). But his greatest honours and services were in relation to India. And it was right it should be so. President of the Asiatic Society of Bengal 1930-1931, he received the Barclay Memorial Medal in 1931 and the Annandale Memorial Medal in 1947. Through the width of his interests, in 1946 he became Adviser to the Government of India on the reconstruction of the Zoological Survey of India and on the formation of the Anthropological Survey and of the Natural Institute of Sciences of India in 1936, of the Indian Association for the Cultivation of Science in 1943, of the Indian Academy of Sciences in 1949, of the Indian Academy of Zoology in 1954, and Honorary Foundation Fellow of the Zoological Society of India in 1949. He was also elected an Honorary Member of the Marine Biological Association of India in 1959. These honours indeed reflect his greatest work. Few things today are as important as the active development of close and happy intellectual relationships and understanding between men of different nations and different cultures. Seymour Sewell's friendship and work for India has done an outstanding service both to us and to the Indian nation.

Colonel Sewell's wife, Dorothy, died in 1931. To their daughters, Miss DR Sewell, whose distinction in the nursing profession has already been noticed, and Dr M Elizabeth Sewell, the distinguished English scholar, we offer our sympathy.

CFA PANTIN

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